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JULY 1959

Drivers
The National Highway Program
Research in Highway Construction
Texas Expressways' Economic Impacts
Central Area Redevelopment in Detroit
Traffic Forecasts by Multiple Regression
Public Works and Traffic Engineering
Lighting the Connecticut Turnpike
Urban Renewal and Transportation
Palo Alto's Unique Renewal Plan
New Orleans' Seven-Cent Fare
Freeways Are Not Enough

THE ENO FOUNDATION FOR HIGHWAY TRAFFIC CONTROL

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Traffic Quarterly

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Drivers

As Americans, we have a national pride in our efforts and accomplishments. We are proud, not arrogant, we enjoy competition and like to do things well.

These comments of self-esteem are not intended to be ostentatious, but only to emphasize a conspicuous exception to the rule. It is difficult to account for our poor driving with its shameful consequences. Occasionally there are signs of minor improvement, but the records remain shocking and disturbing to the public. The problem warrants rigorous, inflexible corrective measures, and the end of our prolonged tolerance of this national humiliation.

With constant effort, qualified personnel, boundless laws and regulations, good roads and good cars, the problem of poor driving remains an enigma. It warrants a serious examination of our procedure.

We need to fundamentally change the attitude of the driving public, but not with erratic, so-called "crackdowns."

Obviously, the three agencies now principally concerned in the issuance of driving licenses and assurance of their proper use or revocation are the state licensing commissioner, the police and the courts. They are the constituted authorities and must necessarily work in unison, with a mutual and sympathetic understanding of their cohesive efforts.

There are few attainments in this country that are more eagerly desired or sought after than car ownership and an operator's license, but, on the contrary, once they are acquired, there is nothing more readily abused.

It is in these areas that we might well strengthen our efforts to improve our driving and gain a much-needed public support.

With regard to licensing, many applicants approach their licensing examinations with real apprehension, but having qualified, become jubilant and only slightly impressed with the importance and seriousness of the newly-acquired privilege.

The fortunate recipient of the new privilege should receive fair

warning that a failure to drive in strict accordance with the conditions of the issuance of his permit, will result in its prompt withdrawal. Appropriate authorities should be unfailing in adhering to this precept.

Your failure over a long period of driving to receive a summons or warning is little indication that you are a good driver. It is probable that you have consistently violated many rules of the road including the civilities due your fellow drivers.

At present there is an absence of an effective motive to drive well at all times. There should be one, leaving no doubt of its close association with the privilege to drive.

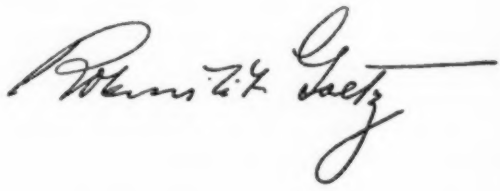
We should recognize that with the growth in population, car registrations, and increased motor travel, our present efforts to control driving may no longer be suitable or adaptable to these changing conditions. As has often been said, "We cannot place an officer on every car."

There should be no necessity for a ridiculous or domineering degree of enforcement. It would not meet with public acceptance.

Driving can be made safe and efficient without unnecessary imposition only when we remove the bandits from the highway.

If we seriously consider the full consequences of bad driving, our efforts and zeal in restricting poor driving bear little comparison to the determination and perseverance characteristic of other law enforcement agencies. Our present system has little deterrent value; it is widely and thinly spread.

An unwavering attitude to revoke the privilege of driving as readily as we grant it will create an upsurge of better driving and essential public support.



The National Highway Program

ELLIS L. ARMSTRONG

Mr. Armstrong has been U. S. Commissioner of Public Roads since October, 1958. For eighteen years he was with the U. S. Bureau of Reclamation, working on design and construction of projects in Western states, including dams, railroads, highways and appurtenant works. In 1953, he served as engineer member of the Egyptian-American Rural Improvement Commission, Cairo, Egypt, on long-range plans for developing land, water, and transportation resources; he also acted as special consultant to the Egyptian government on the High Aswan Dam. In 1954, Mr. Armstrong was Project Engineer of the power portion of the St. Lawrence Seaway for consulting engineers designing, supervising and managing the project for the Power Authority of the State of New York. Subsequently, he became construction manager and then assistant manager for the $700 million project. In 1957, he was appointed Director of Highways for the State of Utah to reorganize the Highway Department and initiate Utah's accelerated highway program. Mr. Armstrong is a member of the American Society of Civil Engineers, the American Association of State Highway Officials, and the U. S. Committee on Large Dams.

WHEN the Federal-Aid Highway Act of 1956 was enacted into law, implementing President Eisenhower's "grand plan" for improvement of the nation's highways, the most sanguine optimists seemed to expect ribbons of pavement to unroll across the land almost the very next day; the most apprehensive pessimists doubted that the program would ever move forward according to the planned schedule.

More knowledgeable, level-headed highway officials recognized that serious problems lay ahead—such problems as engineering manpower, contractors' and materials-suppliers' capacity, and development and application of new techniques for new needs. These officials anticipated a period of a year or two during which these problems would have to be met squarely and resolved. They recognized, too, that the manifold details involved in producing plans and specifications, the acquisition of rights-of-way, and the

extensive work of grading and drainage necessarily precede the laying of pavement and finally the ribbon-cutting symbolizing that a brand-new highway is open to traffic. They anticipated the time that is required to get the "pipeline" full for a program of this magnitude and concept.

More than two-and-a-half years have now elapsed since the 1956 Act was passed. Both the pessimists and the optimists were wrong, and the realists were right; the program is now in high gear and is still accelerating. The anticipated problems of engineering and production have been met and overcome. A different kind of problem, and one less widely anticipated at the beginning, now faces us—the problem of financing. More on that later.

How is it that we have achieved what to some appeared impossible? Foremost, perhaps, is the fact that the 1956 Act made us pioneers again. The great highway construction program laid out before us is an intense, invigorating challenge to everyone in the highway industry, particularly the state and federal highway engineers and administrators who must carry it to fulfilment. But it is a challenge that had been faced before—true, on a smaller scale; but that former challenge was just as real, just as formidable in its day.

It began, of course, with the invention of the automobile in 1893. At that time there were about two million miles of rural roads in the country, and they were almost all just plain dirt roads. The cities had done somewhat better, but not much. The local governments had the entire responsibility for what little was done in highway improvement. Beginning about the turn of the century, the states commenced to recognize the broader-than-local interest in roads, first through financial assistance to the counties and then through establishment of state highway systems built and operated by state highway departments.

In 1916 the Congress launched the policy of providing federal-aid money to the states for road construction. From the very beginning, there developed a close, practical working relationship of co-operation between the Bureau of Public Roads, which was designated to administer federal highway aid, and the state highway departments. So, during the 1920's and 1930's, they got the farmer up out of the mud and developed a pretty fair transportation system across the country. They pioneered in those days, too, in

design and construction techniques. Few, however, envisioned the tremendous future growth of motor-vehicle transportation; and in any event, there never was enough money to build for the future.

Thus, well before World War II it was evident that the highway builders were losing ground in relation to highway needs; and the hiatus of the war increased the gap. In the first postwar decade this foreboding situation continued, despite increased federal and state spending. Traffic pressures, accidents and their personal and property costs, and the aggravation and expense of congestion and delay were grim and growing reminders of the need for action.

It was in this atmosphere of almost desperate necessity that the Federal-Aid Highway Act of 1956 was drafted. For the first time in the half-century of the motor vehicle's life, a definite plan and time-table was created for the completion of a nationwide network of freeways built to meet the present needs and the needs of a few years ahead—the National System of Interstate and Defense Highways. At the same time, greatly increased provision of federal aid was made for primary and secondary roads and their urban connections.

The groundwork had already been accomplished. Federal aid for many years had been confined to main rural roads. The Federal-Aid Highway Act of 1944 broadened this scope, authorizing the first specific funds for federal aid in urban areas. It also provided for the selection of a secondary system of farm-to-market roads, to be improved with federal aid. And in addition, it created the interstate system of 40,000 miles—increased to 41,000 by the 1956 Act—to link the important cities and industrial centers of the country. Comprising only about one percent of our total road and street mileage, this key network when completed will carry twenty percent of all traffic.

But it was not until the 1956 Act that provision was made for completion of the interstate system, built to high standards and adequate for the needs of traffic anticipated in 1975. The scope of the whole highway problem can be measured by expected growth. There are now more than 3.4 million miles of roads and streets in the United States, serving 176 million people who drive their 68 million cars, trucks, and buses some 650 billion vehicle-miles a year. By 1975 there will be well over 200 million people, with more than 100 million vehicles traveling more than a trillion vehicle-miles a

year. Probably our total mileage of roads and streets will not be greatly more than it is now, but surely its quality and capacity must be vastly improved to meet the need.

The core of the highway transportation network obviously is the federal-aid systems, for though they comprise only 24 percent of the mileage, they are now carrying 61 percent of all traffic. These systems total 810,000 miles of roads and streets, including the 41,000 miles of the interstate system. The Federal Government contributes 90 percent of the interstate system project costs, and 50 percent of the cost of projects on the federal-aid primary and secondary systems and their urban extensions (the so-called ABC program).

How well the program under the 1956 Act, as supplemented by the Federal-Aid Highway Act of 1958, has been launched is indicated by a single figure: as of March 31, 1959, federal-aid highway work under way had reached a record high of $7.2 billion, an increase of $2 billion over the same date a year previous. That the program is balanced is evidenced by its division: 59 percent of this work is on the interstate system, 41 percent on the ABC program.

The status of the program on March 31, 1959, and a year previous, in terms of work under way, is shown in detail in Table 1. But this is still not the peak expected to be attained. By July 31,

Table 1

STATUS OF WORK UNDER WAY IN THE FEDERAL-AID HIGHWAY PROGRAM, MARCH 31, 1959, AND MARCH 31, 1958

		Total cost (millions)	*Federal funds (millions)*	*Miles*	*Number of bridges*
Interstate System:	3/31/59	$4,230	$3,660	4,421	4,467
	3/31/58	2,875	2,266	2,955	2,785
	Increase	1,355	1,394	1,466	1,682
Primary, Secondary and Urban (ABC) Program:					
	3/31/59	2,955	1,588	27,697	5,756
	3/31/58	2,311	1,190	22,451	5,176
	Increase	644	398	5,246	580
Total Federal-Aid Program:					
	3/31/59	7,185	5,248	32,118	10,223
	3/31/58	5,186	3,456	25,406	7,961
	Increase	1,999	1,792	6,712	2,262

when the construction season is in full swing, it is estimated that federal-aid work under way will rise to about $8.1 billion, including $6 billion of federal funds. On the same date in 1958 the comparable figures were $6.1 billion total and $4.2 billion of federal funds.

The figures just cited represent only work under way and include the costs of surveys and designs and right-of-way acquisition in process, as well as actual construction under way. In terms of road-building accomplishment, construction projects were completed on nearly 72,000 miles of highways at a cost of $5 billion, under the federal-aid programs from July 1, 1956, to March 31, 1959, as shown in Table 2. Of the total, interstate system projects involved only one-twentieth of the mileage, but accounted for one-fifth of the cost.

Table 2

FEDERAL-AID CONSTRUCTION COMPLETED, JULY 1, 1956 TO MARCH 31, 1959

	Total cost (millions)	*Federal funds (millions)*	*Project miles*	*Number of bridges*
Interstate System	$1,091	$ 856	3,587	2,452
ABC Program	3,983	2,054	68,327	11,344
Total	5,074	2,910	71,914	13,796

Progress on the interstate system is truly remarkable. Because of their dimensions and complexity, interstate projects usually require at least several years for planning decisions, location, survey, and design, and acquisition of right-of-way, before actual construction can begin.

Many sections, furthermore, are being built in stages: a grading project in one year and a paving project the next, for example. With some sections opened to traffic, a two-lane pavement may have been built now, with an additional two-lane pavement planned for construction some years in the future, when traffic growth warrants it.

The accomplishment is impressive. As outlined in the report of progress submitted to Congress in January, 1959,[1] more than 1,500 miles of the interstate system financed with interstate funds had been completed and opened to traffic in two-and-a-half years. This

1. Progress Report on the Federal-Aid Highway Program, House Document No. 74, 86th Congress, 1st Session. U.S. Government Printing Office.

mileage, added to that completed to acceptable standards as toll or free roads prior to passage of the 1956 Act and since, gives a total of 4,700 miles of the system available to the motorist. Even more impressive is the overall record of the two-and-a-half years: work was actually in progress or completed on some phase—either construction, or right-of-way acquisition, or plan preparation—on more than 28,000 miles of the 41,000-mile interstate system. These accomplishments are illustrated in Figure 1, taken from the report to Congress.

While all of these measures of progress present a striking picture, the question still may rise—are we doing as well as we should be? The answer is yes, unqualifiedly. In 1956, when the new program began, federal-aid funds were used in the amount of less than $800 million; in 1959 it is estimated that the amount will approach $2.75 billion. With these expenditures, matched in appropriate ratio by the states, the program is well on schedule.

At the end of March, federal-aid funds for the interstate system for the country as a whole had been obligated in a total amount equaling all of the apportionments still available for the years prior to fiscal 1959, and 97 percent of 1959 funds, although fiscal year 1959 was only three-fourths gone. Similarly, the ABC federal-aid program funds had been obligated to the extent of 84 percent of the 1959 apportionments, again with one-fourth of the year remaining. The 1960 apportionments have been made, and already one-third of the states have begun to obligate those funds.

The Problem of Adequate Financing

The program is on schedule. But facing us is the serious problem of adequate financing for the interstate system. It is hoped that by the time this is in print, the problem will be resolved but it is well to take a good look. The Federal-Aid Highway Act of 1956 authorized nearly $25 billion for the interstate system, spread over the years 1957–69. The companion Highway Revenue Act established the Highway Trust Fund to receive revenues from the federal motor-fuel and certain other highway-user taxes; from this fund the federal share of highway project costs, both interstate and ABC, would come; the ABC program having first call on the funds. The anticipated schedules of receipts and expenditures were ex-

pected to be in close balance, although not on a year-by-year basis.

The 1956 Revenue Act also included a fund-regulating feature commonly known as the pay-as-you-go clause, which requires that the prescribed authorizations be diminished in apportionment if it appears that the trust fund balance would be insufficient to meet payments as the states make their claims for reimbursement.

Revenue accruing to the trust fund during the fiscal years 1957 and 1958 exceeded the original estimates slightly, and on December 31, 1958, there was a balance remaining of $526 million. However, the Federal-Aid Highway Act of 1958 increased the original interstate authorizations by $800 million, stepped up the regular (ABC) authorizations above the previous levels, and provided an additional $400 million as a special anti-recession measure. In addition, the 1958 Act set aside the pay-as-you-go clause for two years.

As a consequence, federal-aid expenditures are expected to exceed revenues for fiscal 1959 and 1960. Thus, unless additional revenue is forthcoming, the pay-as-you-go clause—automatically becoming effective again after its two-year suspension—will make it necessary to forego completely apportionment of the $2.5 billion of interstate funds authorized for fiscal 1961 (which would normally be made this summer), and the apportionment for fiscal 1962 would be limited to $500 million instead of the $2.2 billion authorized. For the remainder of the program, fiscal years 1963–69, available interstate funds would amount to $1.7 to $1.8 billion a year, or three-fourths of the amounts authorized.

Obviously, such a reduction in interstate funds would have a serious and widespread impact on the progress of this vital program which is now in full swing with the pipelines full. It is for relief from this situation that President Eisenhower recommended, in his budget message, that the federal motor-fuel tax be increased by one-and-a-half cents per gallon for the period from July 1, 1959 to June 30, 1964. During that time two important studies will have been completed: the Bureau of Public Roads highway cost allocation study,[2] and the American Association of State Highway Officials' gigantic road test in Illinois. From these studies will come a wealth of information—although certainly not the precise answers to everything—to guide the Congress in a fresh look at the federal

2. Third Progress Report of the Highway Cost Allocation Study, House Document No. 91, 86th Congress, 1st Session. U.S. Government Printing Office.

role in highway responsibility and the equitable distribution among highway users and other beneficiaries of highway costs.

With these data at hand in 1961, Congress can examine carefully the full picture, including the problem of the increased cost of the interstate system, with the benefit of detailed current information, and formulate the full program for completion of the designated interstate system and continued improvements on the regular ABC systems.

It would be unfortunate if the momentum now attained by the highway industry should be lost, and that would inevitably happen if interstate funds were stopped or severely curtailed for several years. The build-up of the last few years would have to start all over again. The consequence of such a let-down on the highway industry and on the economy generally would indeed be serious.

Beyond the federal financing problem looms an equally serious one—that of the states and local governments in matching federal aid and meeting the increasing highway needs outside of the federal-aid program. Although interstate funds are provided on a ninety percent federal, ten percent state basis, the sheer volume of the state matching requirements, plus the fifty-fifty matching basis for the now very large ABC program, places many of the states in the position of being hard pressed to match the federal aid that is available to them.

Over the years, federal aid used to constitute about one-eighth of the annual capital outlay for highways, and the equality of the federal-state sharing was on a project-by-project basis. But now, in 1959, capital outlay for all roads and streets will total something over $7 billion, of which federal funds will account for more than forty percent. The Federal Government is approaching equal partnership, not just in projects, but in the total highway construction program. The earlier balance can only be regained by acceptance of substantially increased responsibility by state and local governments in the mounting costs of meeting the nation's highway transportation needs. A number of states, in fact, are considering increases in their motor-fuel tax or other taxes for highways.

It is imperative, then, that highway administrators and engineers get the most from the funds provided them. It is gratifying to look in this direction, especially after viewing the clouded financial picture.

The contracting, materials-supply, and roadbuilding-equipment industries met the challenge of the 1956 Act promptly. There seems no doubt that the six thousand highway construction contractors in the country, with their $2.7 billion investment in 350,000 major equipment units, have the capacity to carry the construction program adequately, even at its anticipated peak.

Improved Technology Lowers Costs

Improved technology over the years, through efforts of both the contracting and the equipment-manufacturing industries, has held the rise in highway construction prices to a lower level than the increase of most prices in the economy; without the progressive improvement of the last thirty years, prices of roadbuilding work would be at least double what they are today. The greatest gain has been in earthmoving work, where equipment development has been spectacular and no materials are used. Unit costs of earthwork are no more today than they were thirty-five years ago.

Comparable advances in pavement work have not been quite as marked for, although there has been much improvement in equipment, large quantities of materials are involved. Development of new equipment and techniques holds great promise for the future, for faster, better, and more economical paving. For example, the slip-form concrete paver has demonstrated its ability to lay plain or reinforced concrete. Faster operation of bituminous pavers has been found practical and productive.

Structure costs have risen considerably over the years, primarily because of the materials involved and the large amount of labor required. Here, too, technology has been at work. New types of steel, steel welding and bolting techniques, precast and prestressed concrete, and possible use of aluminum in standard bridge shapes or completely new designs, may well have a beneficial effect on bid-prices through competition.

Actually, all unit prices of highway construction are considered reasonably moderate, in comparison to the general price structure; the cost of highways looms large today primarily because of the greater needs of traffic. The modern highway with its large traffic volumes requires more and wider lanes, better shoulders, stronger structures, and flatter curves and grades than the road of a few

decades ago, and such necessities of today as grade-separated interchanges and controlled access did not even exist commonly in earlier years.

When the Act of 1956 initiated the huge new highway program,

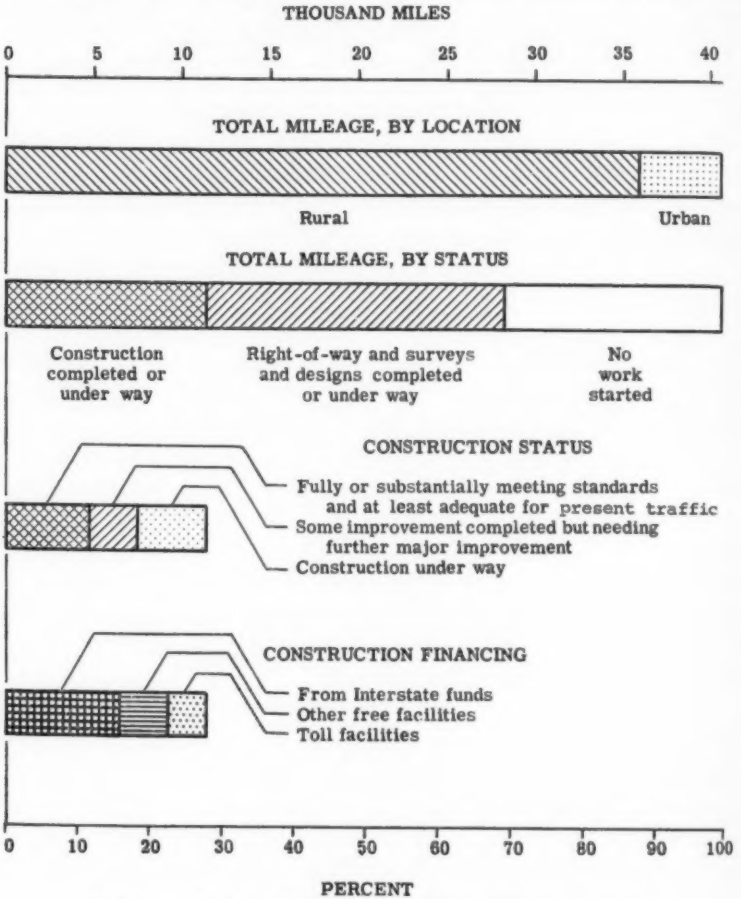


Figure 1. Status of interstate system of improvements as of December 31, 1958.

a major concern of highway officials was the expected serious shortage of engineering manpower. The shortage did indeed develop, but a vigorous attack in a variety of ways has very largely resolved the difficulties initially encountered. Some of the states were able

to adjust salary scales upward to meet at least to some extent the scale of private industry. Some carried on active recruiting campaigns in the colleges and high schools, and initiated special training courses for old and new employees alike. Studies of employee utilization led to creation or expansion of engineering-aid and technician staffs, freeing engineers from work requiring lesser skills, knowledge, or capabilities. Consulting engineers were used more extensively to supplement the highway department staffs.

At the same time, remarkable instruments and techniques were coming of age and receiving widespread attention and application, such as aerial surveying and photogrammetry, geophysical techniques for sub-surface exploration, and electronic distance-measuring apparatus.

Seemingly the most versatile of all among the new tools available to the engineer is the electronic high-speed computer. Man has come a long way since the first cave dweller learned to count on his fingers. The decimal system of numbers, logarithms, the slide rule, adding machines and desk calculators, and punch-card sorters and tabulators have vastly increased man's ability to count and calculate. Now, with the electronic computer, man's counting fingers are incredibly multiplied and accelerated. Certainly the machines cannot think, and the development of a "program" of directions for the machine to follow is painstaking and time-consuming; but once the pattern of instructions is prepared the computer can process data with almost unbelievable speed. The immediate utility of the computer is evident: the engineer is relieved of the drudgery of computations, and the results are available far sooner. Even more attractive is an extension of this utility: problems of great complexity may be undertaken now that were simply impossible heretofore in terms of available manpower and time.

The Bureau of Public Roads now has a library of more than 250 programs for solving highway design problems and the list is growing steadily. These are available to the states and their consultants, thus pooling the collective knowhow of the highway engineering field.

Examples of the use of computers and other electronic devices crop up in varied fields with increasing frequency. The highway locator can now explore the physical and economic practicality of six or eight or more alternate alinements for a new road between

two control points in a fraction of the time it formerly required to compare only two or three. Similarly, the bridge designer is able to select the best design from a whole series of trials. These advances are improving the quality of highway design and construction.

In an entirely different field, origin-destination traffic studies, formerly eschewed by the largest cities because of the impossibility of manipulating the vast amount of data involved, are now practical and under way in great metropolitan areas such as Chicago. Selection of the best location for a proposed urban freeway by assignment of potential traffic on the basis of travel time and distance savings is another burden that can now be assumed by the computer.

There is a popular office saying, of many variations: "I have so many immediate problems, I have no time for the important ones." Relief from mechanical drudgery can free the engineer for the important problems; roadbuilding is advancing step by step from an art toward becoming a science.

This is not to imply that we have disposed of all of our immediate problems; but we are devoting more time to important ones. In the field of highway design, for example, forward-looking engineers have come to recognize the advantages of locating divided highways, not as a four-lane unit with a fixed median and level cross-section, but as two separate roadways each independently fitted into the terrain to best advantage, yet with consciousness of the impact of one—in headlight glare, for instance—on the other.

In the area of highway construction, specifications are being examined for improvement that will result both in quality and economy, as well as greater uniformity among contract-letting highway authorities. There is a trend toward development of end-result specifications, which have real advantages in some phases of highway work. These would spell out only the required quality of the finished work, rather than how it is to be accomplished. Contractors may then use their ingenuity to devise new techniques, and equipment manufacturers may introduce experimental new machinery without hampering restrictions, so long as the "product" is good. The highway is indeed a manufactured product; it differs from other manufactures only in that the factory is a mobile one, turning out the product in the place where it will be used. Encouragement of contractors and equipment builders to seek new methods can well result in better, more economical roadbuilding.

Still a different, important field in which the knowledge and the capabilities of engineers must be employed to the fullest extent possible is the planning of urban freeways and highway transportation systems. Here it is not just a question of providing facilities with adequate capacity, but of attempting to foresee and plan for future growth and change, and to weigh the impact of the facilities on adjacent property and on business and industry of the community as well.

Highway engineers are not so smug as to assume that, given relief from the "immediate" jobs, they can accomplish all of the important ones perfectly, with their present knowledge. Only within the last year, for example, the Bureau of Public Roads has found that by proper inlet design the capacity of culverts can be increased by nearly a third—and the research incidentally demonstrated that earlier theory of flow through short pipes was in substantial error.

In another eminently practical field, studies of aggregate drying are under way, for nobody really knows at what temperatures or how fast aggregates should be dried for best and most economical results.

On a far grander scale, the AASHO Road Test in Illinois is studying the effect of controlled traffic of known weight and measured volume on 836 test sections of both rigid and nonrigid types of pavement of varying design. In its extremes, the test ranges from sections on which tandem-axle loads of 48,000 pounds roll over twelve-and-a-half-inch portland cement concrete and comparably strong bituminous pavement, to sections literally with no load or almost no load. From this test, it is hoped, will come not only direct applications in structural design but also the development of sound theories of design that will have broad future use.

Almost esoteric by comparison is a Public Roads study of the surface area of the submicroscopic mineral particles of different kinds that compose clays. Lest this research seem impractical, bear in mind that clays are the commonest of soils on which our roads are built, and often troublesome foundation materials; yet we really know little about them.

Turning from the microcosm to the metropolis, a variety of studies have been made and continue, by Public Roads and others, on the travel patterns and travel habits of residents of large urban

areas. From these are gradually developing techniques useful in the prediction of future traffic growth and pattern changes.

Important as it is to improve our knowledge of highway planning, design, and construction, we must remember that highways are built for but one reason—to serve the people. It is vital, therefore, that we consider with equal thoroughness the road, the vehicles that operate upon it, and the people who drive these vehicles. Much of the knowledge—and lack of knowledge—about these three elements of highway transportation and their interrelations has been presented in a recent study of highway safety reported to the Congress by the Bureau of Public Roads.[3]

Of course, we cannot suspend all roadbuilding until the many and varied research studies under way or actively contemplated are brought to completion. On the constantly expanding frontiers of science so often referred to, highway engineering is no exception; and it is a reasonable supposition that as long as man retains the trait of curiosity and the capacity for thinking, new and better ways of doing things will continue to be found—and each discovery will reveal new avenues for further exploration.

Meanwhile, highway construction cannot wait, for the long-suffering motorist cannot. We need vast road improvements and we need them now. The story of the need has been told countless times, in millions of words and statistics. It can be summed up briefly as follows: we need greater capacity, safety, and convenience.

We have a tremendous construction program under way, and in both quantity and quality the accomplishments under that program have been most creditable. New developments of proved merit will be incorporated into the program as quickly as they arise, and undoubtedly there will be many. But even now the highway engineers and administrators, the contractors, and the equipment and materials-supply industries have the will, the ability, and the capacity for the job that lies ahead.

3. "The Federal Role in Highway Safety," House Document No. 93, 86th Congress, 1st Session. U.S. Government Printing Office.

The Research in Highway Planning and Research in Construction

G. DONALD KENNEDY

Mr. Kennedy is President of the Portland Cement Association, with which he has been affiliated since 1950—as consulting engineer and assistant to the president, executive vice president, and since 1954 as president. Previously, he was from 1933 to 1942 with the Michigan State Highway Department, as Deputy State Highway Commissioner and later as State Highway Commissioner. From 1943 to 1950, Mr. Kennedy was Vice President in charge of Highway Development of the Automotive Safety Foundation. He is a Registered Civil and Professional Engineer in the District of Columbia and eleven states, including California, and has served as consultant to several states on the development of long-range highway programs. During the 1940's, Mr. Kennedy was a member of the Highway Traffic Advisory Committee to the War Department, Vice Chairman of the President's Inter-regional Highway Committee, and a member of the Public Works Task Force of the Hoover Commission. He is a member of the American Society of Civil Engineers, the American Society of Planning Officials, the Institute of Traffic Engineers, and in 1942 was president of the American Association of State Highway Officials. Mr. Kennedy received the George S. Bartlett Award for "Outstanding Contribution to Highway Progress" in 1946. He is the author of numerous engineering reports prepared for special and technical committees, and in 1955 was Chairman of the Highway Research Board, National Academy of Sciences.

HIGHWAY transportation is the largest single economic activity in the United States. Highway construction is one of the nation's major industries; more than $5 billion worth of roadbuilding was under contract early this year. And this figure is growing as the expanded highway program gets into full swing. These large expenditures for construction have important effects in themselves, but more important is their profound future effect on highway transportation. Obviously they must be planned soundly, on the basis of factual knowledge, if they are to provide the benefits

expected of them. Such factual knowledge is obtained by research in highway planning, design and construction; and this research has inevitably grown in amount and importance along with the growth in construction.

One of the most striking things about present-day highway research is its breadth. Because highway transportation occupies such a paramount place in American life, highway research must consider practically every aspect of our economic, social and even personal activities. Highway research is conducted by mathematicians, physicists, chemists, meteorologists, bacteriologists, physicians, psychologists, botanists, anthropologists, sociologists, and every kind of engineer. Few, if any, scientific and engineering disciplines do not play a part in it.

Only a few years ago, roadbuilding was the exclusive province of the civil engineer who knew how to route a road economically through various types of terrain and how to design adequate pavement and structures. Roadbuilding has changed fundamentally in recent years. It now involves a complex technology which is dependent for advance on large-scale research.

A relatively small number of organizations have been responsible for much of the large-scale highway research done in the United States. Among them are the Bureau of Public Roads; the American Association of State Highway Officials and the various state highway departments; the Highway Research Board of the National Academy of Sciences, and the Automotive Safety Foundation. Important work, although usually on a smaller scale, has been done by many universities, and such groups as the Eno Foundation and the Brookings Institution.

The Bureau of Public Roads has counted research among its major activities since its creation by the first Federal-Aid Highway Act in 1916. It is presently conducting several research projects of fundamental importance, which will be described later in this article.

The American Association of State Highway Officials has been active in co-ordinating various state programs with each other and with the work of the Bureau of Public Roads. AASHO also sponsors specific research projects of benefit to all state highway departments.

The Automotive Safety Foundation has pioneered in "highway needs" studies as a basis for long-range planning, and has also done

important work in highway finance, administration and planning.

An indispensable forum and co-ordinating body is provided by the Highway Research Board. This group was formed in 1920 as an agency of the National Research Council of the National Academy of Sciences. It is at present the most important group for bringing together data on research in all phases of highway planning, design and construction.

Some Important Current Research

The Federal-Aid Highway Act of 1956, which inaugurated the present expanded highway program, also directed the Bureau of Public Roads to make several studies that will have a profound effect on future public highway policy. Two of these studies of special interest are concerned with safety and economic benefits of highways.

In the safety study, the Bureau has included psychologists, physicians and engineers in teams who probe deeply into the causes of specific accidents. This study, by far the most comprehensive yet made, should point the way toward more effective action to reduce our appalling accident toll. Results have been presented to Congress and will be published soon.

National Test Road

The study of economic benefits of highways is of fundamental importance in establishing a national policy on highway financing. In the past, highway construction has been financed primarily by taxes on highway users. But others receive substantial monetary benefits from improved transportation. There is also the question of the additional cost of providing roads adequate for heavy trucks as well as for private automobiles. Controversy on these problems has hindered highway development in the past. The definitive Bureau of Public Roads study now under way should help in formulating an equitable solution to the problem of financing. This will be of incalculable value to rational highway planning.

Another area of intense controversy is being attacked directly in the National Road Test at Ottawa, Ill., sponsored by the American Association of State Highway Officials and the Highway

Research Board. This $22 million project aims to evaluate various types and designs of pavement and structures, and the cost of providing facilities adequate for various types and weights of vehicles. Results will have an important effect on the types of construction used in future highways, although they will, of course, be evaluated in light of local conditions. The Test Road is the most expensive and comprehensive single research project ever undertaken in the highway field.

Origin-Destination Studies

A key role in highway planning is played by origin-destination studies, which tell, in effect, the traffic density to be expected over various routes. The Bureau of Public Roads has pioneered in these studies over the last twenty years and they form the basis of many highway plans of today. For example, Chicago conducted an elaborate origin-destination study in 1941 which was used as the basis for design of its expressway system currently under construction.

Such studies are still important to urban highway planning. But in an extremely dynamic society, they are obviously incapable of telling the full story. At present, a premium is placed on the ability to forecast future growth so as to avoid the congestion that seemed to follow automatically on yesterday's highway developments. This is of greatest importance in urban areas.

Urban Research

Urban research has assumed a pre-eminent place in highway planning because of the complexity of urban transportation needs, and the fact that practically all our population growth is occurring in urban areas. In the next sixteen years, population growth in metropolitan areas is forecast at from twenty-five to forty percent, while rural population remains practically stable. Cost estimates for completion of the interstate system show that urban highways, accounting for less than twelve percent of the mileage, will require more than half the total expenditure.

A modern urban traffic artery is so completely different from its forerunners that it usually is even given a different name, such

as freeway or expressway. These highways must handle traffic movements of a size and complexity unimagined only a few years ago. The extremely high cost per mile of urban construction makes design and location much more exacting problems than in rural areas. Urban highways have a profound effect on future development, land use, and redevelopment plans. They must, therefore, be closely integrated with overall city planning.

The design of entrances and exits for an urban expressway is a complex problem of integrating the expressway with literally thousands of local streets to form a system that is most efficient as a whole. Design of urban systems also involves provision of parking space, integration with transit systems, and ample provision for future traffic growth.

The need for tremendous amounts of data on traffic patterns and growth trends, land use, directions of future development, demographic trends and factors influencing industrial and commercial development, is apparent in planning urban highways. The 1956 Highway Act has made the problem of obtaining and interpreting these data acute because of the limited time contemplated for completion of the interstate system.

Organization of Urban Research

Perhaps the first major national organization to gather and publish information on urban transportation research was the National Committee on Urban Transportation, formed in 1954. This group was organized by six societies in the municipal field representing administration, construction, planning, finance, and law enforcement. Other groups have since affiliated with it, including the Bureau of Public Roads. Financial and staff assistance has been provided by the BPR and the Automotive Safety Foundation.

This committee has published a valuable series of guide manuals to aid city officials in evaluating transportation needs of their communities. These publications were prepared in draft form by some 175 specialists from city, county, state and federal government. The procedures suggested were then field-tested in seven cities before publication. The guide manuals provide detailed information for city officials on how to organize, administer and finance transportation-needs studies, and how to plan and execute improve-

ments based on these studies. This committee has also sponsored substantial work toward improving city-county-state relationships in transportation planning and development.

A Committee on Urban Research has recently been organized within the Highway Research Board to stimulate and correlate research, determine research needs and publish material in this field. This committee is expected to fill a long-felt need for a clearinghouse on urban transportation research.

The Highway Research Board, by its high standards and semi-official status, has become an extremely important positive factor in highway research. It is hoped the Committee on Urban Research will extend its influence more deeply into urban problems.

Under consideration in the National Academy of Sciences-National Research Council is establishment of an Urban Board separate from, and on the same level with, the Highway Research Board. The Urban Board would, of course, be concerned with all types of urban research and not just transportation. Such a group could undoubtedly be of considerable value in co-ordinating urban research and bringing together people from the various disciplines engaged in the study of urban problems.

The pressing nature of many urban research problems was brought out late in 1958 at a conference of federal, city, state and county officials, educators and planners at the Sagamore Center, New York. The Sagamore Conference was set up to explore practical means for integrating the expanded highway program with urban planning, and is already considered a milestone in this effort. It was agreed that more attention should be given to planning by highway construction agencies. This should take the form of co-operation with local agencies wherever possible, but if planning is not undertaken by local authorities, the state must fill the gap.

The great majority of American communities were caught with inadequate plans and planning facilities by passage of the 1956 Highway Act and are striving now to catch up. The accumulated traffic inadequacies—to correct which, Congress saw fit to authorize expenditure of the staggering sum of some $50 billion—make delay unthinkable. A heavy responsibility has been placed on all levels of government to speed up and co-ordinate metropolitan area planning with highway development. The Sagamore Conference helped to emphasize the urgency of this effort and to indicate some of the directions it should take.

The need for better relationships among various levels of government in planning metropolitan highway systems was also the primary subject of the Urban-County Congress held early in 1959 by the National Association of County Officials. This congress was useful in clarifying the role of county governments in transportation planning, as well as in re-emphasizing the absolute necessity of area-wide planning.

An unusually interesting experiment is being undertaken in the Washington, D. C., metropolitan area with formation of the Washington Center of Metropolitan Studies. This is a co-operative effort of the seven universities in the Washington area, together with planning, highway, and various community organizations. Its objectives are to stimulate and disseminate research, develop programs of studies on metropolitan problems in the participating universities, and to conduct programs of education of community leaders on area problems. If successful, the Washington Center will undoubtedly provide a model for other metropolitan areas.

Another center for urban studies has recently been established jointly by Harvard University and the Massachusetts Institute of Technology. This center will be international in scope and aimed more exclusively at research than the Washington Center.

A good example of the kind of co-operation among various agencies needed to plan intelligently for urban transportation needs is provided by San Diego, California. This city's experience might be called research in applying research; San Diego has developed a highly effective administrative organization for planning and executing improvements in its metropolitan area transportation system.

Because of the urgency of applying research to plan efficient urban transportation systems in view of the timetable established by the 1956 Highway Act, the San Diego experience is worthy of special attention. San Diego began its study of the problem in 1954. A first step was made in 1955, when the Office of Transportation Research was established. Under this office is organized an Advance Transportation Planning Team, composed of representatives of the city and county planning and highway departments, and the city traffic department. These men work in one office, but report to their supervisors in the various departments. Thus they provide very close liaison between research and operational departments.

To co-ordinate research with all the governmental units in-

volved, a technical co-ordinating committee meets once a month. This committee is composed of the planning directors, city engineers and traffic engineers of the seven cities in the metropolitan area, the county, and the state highway department. Transit, law enforcement, and other interested groups are also included. This committee has eliminated most of the problems that often occur between the central city and nearby communities.

As the extensive transportation study carried out in San Diego began to move from the research to the implementation stage, it appeared necessary to have a small executive group which could put plans into action and correct administrative problems that arose. This group consists of the assistant city manager, director of public works, city engineer, city planning director and transportation research director.

Comprehensive transportation studies have been carried out under this administrative setup, which is already proving of great value in implementing these studies. All agencies of government in the metropolitan area participate in and are kept informed of research that determines highway needs and priorities. The result is general support for construction programs based on this research.

New Developments

A relatively new concept in highway engineering is the "traffic model." The term "model" means a mathematical expression that describes the actual behavior of traffic. The same basic concept has been in use for many years, but as currently used, the traffic model is considerably more detailed and refined than earlier techniques.

A traffic model usually starts with detailed data on land use, including industrial, commercial and residential patterns, social-economic patterns in residential areas, transit availability, and other factors that have a bearing on traffic generation. From these data, equations can be set up describing observed traffic patterns as a function of known factors, primarily land use. Such equations provide a valuable tool in predicting future traffic needs on the basis of expected growth patterns. Since these growth patterns can be controlled to some extent by zoning laws and other means, traffic models in combination with effective city planning offer hope of

preventing future traffic congestion to an extent that has not been attainable in the past.

The general use of electronic computers is having a tremendous effect on highway and traffic engineering. Although their only function is to speed up calculations, this speedup, with an enormous consequent saving in time and manpower, has made it possible to make the kinds of traffic-flow study that were always necessary, but previously impractical. There is no doubt that these machines have made possible for the first time the full use of all our basic knowledge to plan transportation facilities.

Advances in Roadbuilding

A development in automotive transportation that is perhaps closer than we think is electronic guidance of vehicles. Until quite recently, plans for automatic guidance of individual cars seemed far in the future, if not altogether impractical. But a recent experiment has indicated that a simple strip of metal foil down the centerline of a road may be sufficient for radar guidance of a car. Such developments should alert us to the fact that breakthroughs can occur in this field, and it would be wise to prepare for them.

A discussion of highway research would not be complete without mention of the vast improvements in road construction that have come about through research. Basic research in soils has resulted in great improvement in foundations for all types of pavement and structures. Discovery of the importance of air entrainment and granular subbases has substantially increased the life expectancy of concrete pavements. Prestressed concrete is producing impressive savings in bridge construction costs.

A Step Toward One-Pass Machine

A recent innovation that has aroused particular interest in highway departments is the traveling form-paver. This machine, which eliminates the conventional side forms for concrete pavement, was originally used on secondary roads where extreme smoothness was not required. It has recently been used successfully on interstate routes with the strictest smoothness tolerances. Its performance indicates that side forms may soon be a thing of the past in concrete

paving, with a consequent considerable saving in construction cost. It is a substantial step toward the one-pass roadbuilding machine, long a dream of highway engineers.

Highway research, and especially urban highway research, has greatly increased in importance since passage of the Federal-Aid Highway Act of 1956. The need for an enlarged research program was indicated by provisions of the Act which directed the Bureau of Public Roads to initiate ambitious studies on highway safety, economic benefits, and construction costs.

When funds were made available by the Act for a highway construction program they had long dreamed of, many cities found themselves without adequate knowledge or plans to utilize these funds most effectively. The major task facing highway research today is to provide the knowledge necessary to insure the best possible location and design of the new roads, and to provide it quickly enough so that the expanded roadbuilding program may proceed on schedule. Governmental and highway officials face the equally challenging problem of devising administrative machinery that can put this research to full use in metropolitan areas.

Economic Impacts of Expressways in Dallas and San Antonio

WILLIAM G. ADKINS

Mr. Adkins is head of the Economics Section of the Texas Transportation Institute, and Associate Professor, Department of Agricultural Economics and Sociology, the Texas A & M College System. His professional background includes seven years of research in land economics and studies of both rural and urban land use and land values. He is the author of numerous articles on these subjects, in addition to special reports published by the Texas Transportation Institute: "Effects of the Dallas Central Expressway on Land Values and Land Use"; "Economic Impact of Expressways in San Antonio"; and "Economic Effects of the Camp Creek Road Improvement." Mr. Adkins is a member of the Southwest Land Tenure Committee, the Southern Economic Association, and the Southwestern Social Science Association.

THE United States is committed to a system of superhighways destined to change profoundly the patterns of economic growth across the nation. The 41,000-mile Interstate System is primary, but it will be supplemented by additional thousands of miles of expressways. In the words of the late Thomas H. MacDonald, former Commissioner of the Bureau of Public Roads and distinguished professor at Texas A & M College, "We are entering the express era of highway transportation."

Like the railroads and canals in their eras, the dynamic force of the expressway highway system will revitalize parts of the nation. It will create residential, commercial and industrial sites. It will shift functions as between persons and places. It will generate economic activity, give rise to new industries and products, and bring about new efficiencies. If high-speed, high-capacity expressways will do these things, most certainly too they will create wealth and shift wealth. There will be windfalls and there will be exploded dreams.

Most of us are assured that all these effects and others will be

demonstrated. But our comprehension is hazy, our concepts incomplete. Some authorities on the subject say that expressways will "save" the central business district. Others predict the decadence of the central city because expressways, in bringing places closer together, will supplant the efficiences of the downtown centralized area. Others bypass this argument in favor of the contention that we need expressways regardless of the consequences.

Fortunately, there is a growing endorsement of the belief that research can provide some of the needed answers. There are questions beyond the economic justification of expressways. For example, we are not at all sure who should pay for our new systems of roads. We suspect that we know something of the quantity and incidence of benefits, but we are not sufficiently sure. We need to test our beliefs and, at the same time, seek to comprehend additional problem areas and to evolve methods for studying them.

The term "economic impact" has come to mean more especially the effects of road improvements upon real estate, its value, its use and its users and owners. Economic impact studies have been conceived as a research area that can furnish many of the answers needed by administrators and planners at various levels of government and by large segments of the general public. Certainly, however, the research area is narrow when compared to the over-all inquiry into expressway phenomena. This fact does not deny the importance of economic impact but suggests that it be kept in proper perspective.

The Texas Transportation Institute entered the field of economic impact research in 1955 with a project sponsored by the Automotive Safety Foundation. In later years, the U. S. Bureau of Public Roads and the Texas Highway Department have added their support. At the present time, economic impact studies are underway in nine different locations in Texas. These locations represent a variety of situations: rural, urban, suburban, and bypasses. Three studies have been completed and reported in the following publications: *Effects of the Dallas Central Expressway on Land Values and Land Use*, TTI Bulletin 6; *Economic Impacts of Expressways in San Antonio*, TTI Bulletin 11; and *Economic Effects of the Camp Creek Road Improvements*, TTI Special Report.

The principal purpose of this article is to review the major findings of the Dallas and San Antonio expressway studies. There is no

thought that these studies provide information that sweeps away the unknowns posed in the opening statements. They do not, for they are concerned with expressway effects on adjacent areas in only two cities and over relatively short periods of time. The Texas studies are but a modest contribution to a growing fund of economic impact data being developed in California, Connecticut, Georgia, Washington and other states.

The Dallas and San Antonio studies use the "before and after" approach to determine expressway effects on adjacent lands. Control areas, chosen as comparable to the study or experimental areas, are used to establish comparative data or "yardsticks." Ideally, study and control areas should have been identical in the "before" period. Further, they should have been subjected to the same influences during the period of observation, except that an expressway was introduced into the study area at the point in time between the "before" and "after" periods. Practically, such laboratory conditions do not obtain and thus the requirement is modified to "reasonable" comparability for the two areas in the "before" period, and "reasonable" assurance that the expressway was the major influence operative in one area but not the other.

This scheme is more particularly adaptable to the study of an expressway's impact on land values and business volumes for generally it is accompanied by mathematical treatments. Some quantitative measures of land-use influences are sometimes possible, but the lags and subtleties in land-use change often make differentials difficult to measure. They may be more aptly stated in qualitative terms. Also, potentials for change in use may be reflected almost entirely in the value of land rather than in physical relationships.

In the Dallas and San Antonio studies, measurements were confined to land-value impacts. Business volumes in Texas are unusually difficult to determine because of the absence of general sales taxes or other mandatory accounting systems easily adaptable for research purposes. Thus, descriptive analyses of effects on business and land use were employed in the two Texas studies.

Emphasis is placed on the findings regarding land-value effects of Dallas and San Antonio expressways. Admittedly, these are the most important findings of the two studies, so the restriction is not a serious one.

The Dallas Study

Second in size only to Houston among Texas cities, Dallas is situated in the north central part of the state. The population of its metropolitan area now exceeds 900,000, up from 755,000 in 1955 and 615,000 in 1950. Central Expressway was the first freeway-type facility constructed in the area. It is about thirty miles long, running through the city as U. S. 75 toward Oklahoma City to the north and toward Houston to the south.

A section of 5.4 miles was selected for the economic impact study (See Figure 1). The findings reviewed in this article, however, refer to a still smaller segment—a 3.6-mile stretch with six free lanes and continuous frontage roads. Definite planning for Central Expressway was begun in late 1945, construction was started in 1947 and the portion chosen for study was completed in early 1953.

The study area comprised three bands of properties on each side of the facility. Property abutting the expressway's frontage roads was designated *A Band*. A second strip of land, two to three blocks in width and next to abutting properties, was called *B Band*. *C Band* was composed of still another two to three blocks on each side of *B Band*.

For the study of land-value impact, 1941–45 was selected as the "before" period and 1951–55 as the "after" period. The middle five-year period, 1946–50, also was employed in the analysis. Both real estate sales and tax valuations were used in the study of land-value impact.

Two methods of treating real estate sales data were emphasized in the Dallas study and, as will be seen later, in the San Antonio study. Method I involved the use of sales prices without treatment for the value of property improvements. Method II represented an attempt to remove the value of improvements from the measurements to obtain indexes of the expressway impact on land values only. The value of an improvement was calculated to be its tax valuation treated by an appropriate construction cost index. Under both methods, the algebraic difference between price changes in study and control areas was taken to be the net influence of the road improvement. Such a measure, of course, is subject to statistical and logical tests.

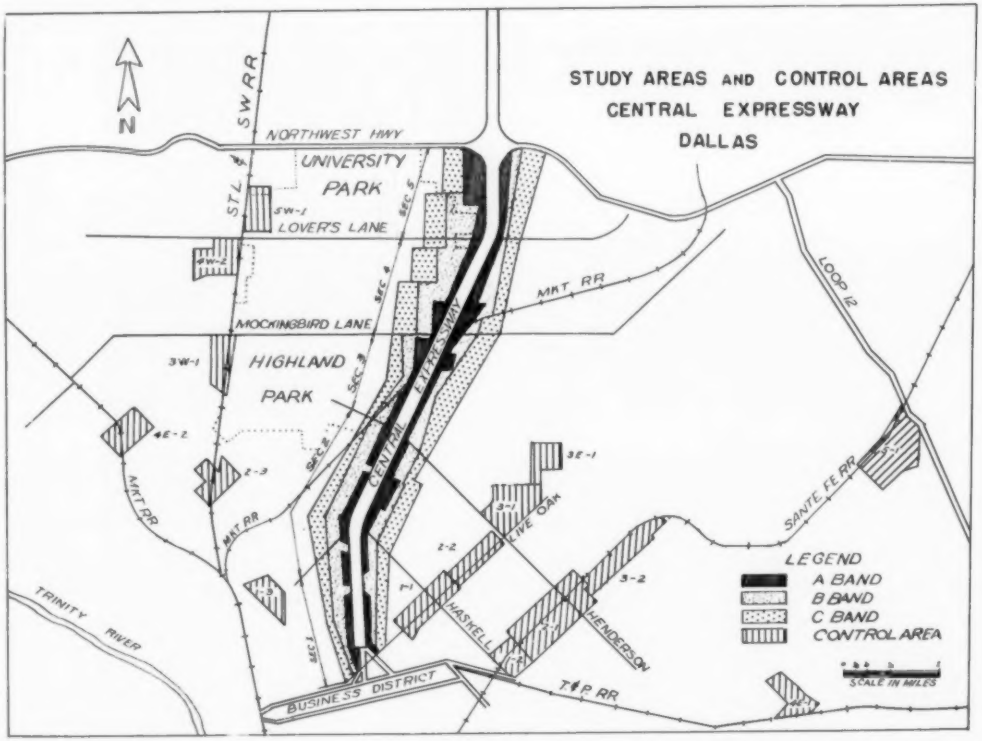

STUDY AREAS AND CONTROL AREAS
CENTRAL EXPRESSWAY
DALLAS
N
SW RR
NORTHWEST HWY
UNIVERSITY PARK
STL
SW-1
LOVER'S LANE
SW-2
MOCKINGBIRD LANE
MKT RR
LOOP 12
HIGHLAND PARK
3W-1
SEC 3
SEC 4
SEC 5
SEC 6
CENTRAL EXPWY
4E-2
2-3
MKT RR
MKT RR
3E-1
3-1
LIVE OAK
SANTE FE RR
2-2
3-2
WASHELL
HENDERSON
TRINITY RIVER
SEC 1
T-1
BUSINESS DISTRICT
T&P RR
LEGEND
A BAND
B BAND
C BAND
CONTROL AREA
SCALE IN MILES

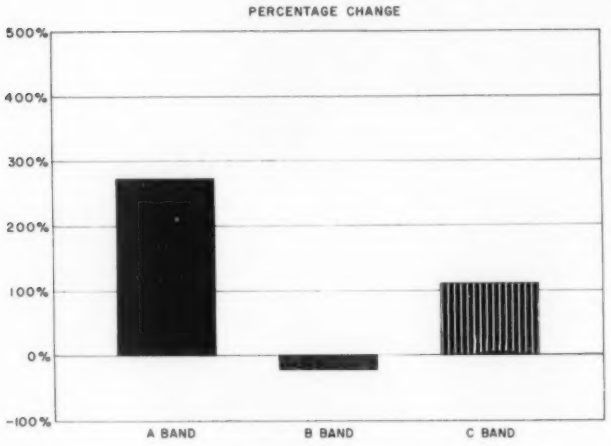
Figure 1.

Figure 2. The 3.6-mile section of North Central Expressway discussed in this article, with downtown Dallas in the background.

DALLAS

NET INFLUENCE
OF CENTRAL EXPRESSWAY
ON LAND VALUES OF ADJACENT AREAS
1941–45 to 1951–55

METHOD 1 MEASUREMENTS



METHOD 2 MEASUREMENTS

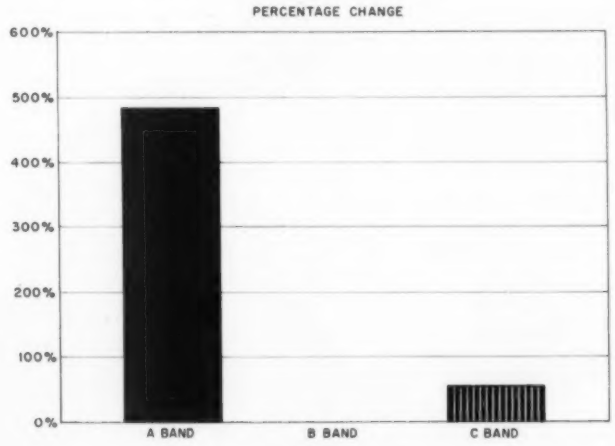
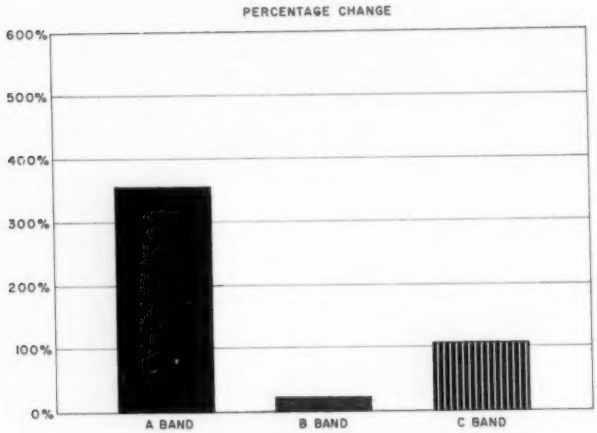


Figure 3.

DALLAS

NET INFLUENCE
OF CENTRAL EXPRESSWAY
ON LAND VALUES OF ADJACENT AREAS
1946-50 to 1951-55
(1941-45=100%)

METHOD 1 MEASUREMENTS



METHOD 2 MEASUREMENTS

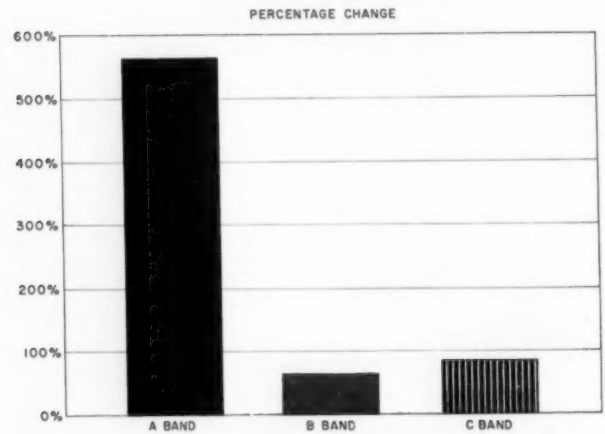


Figure 4.

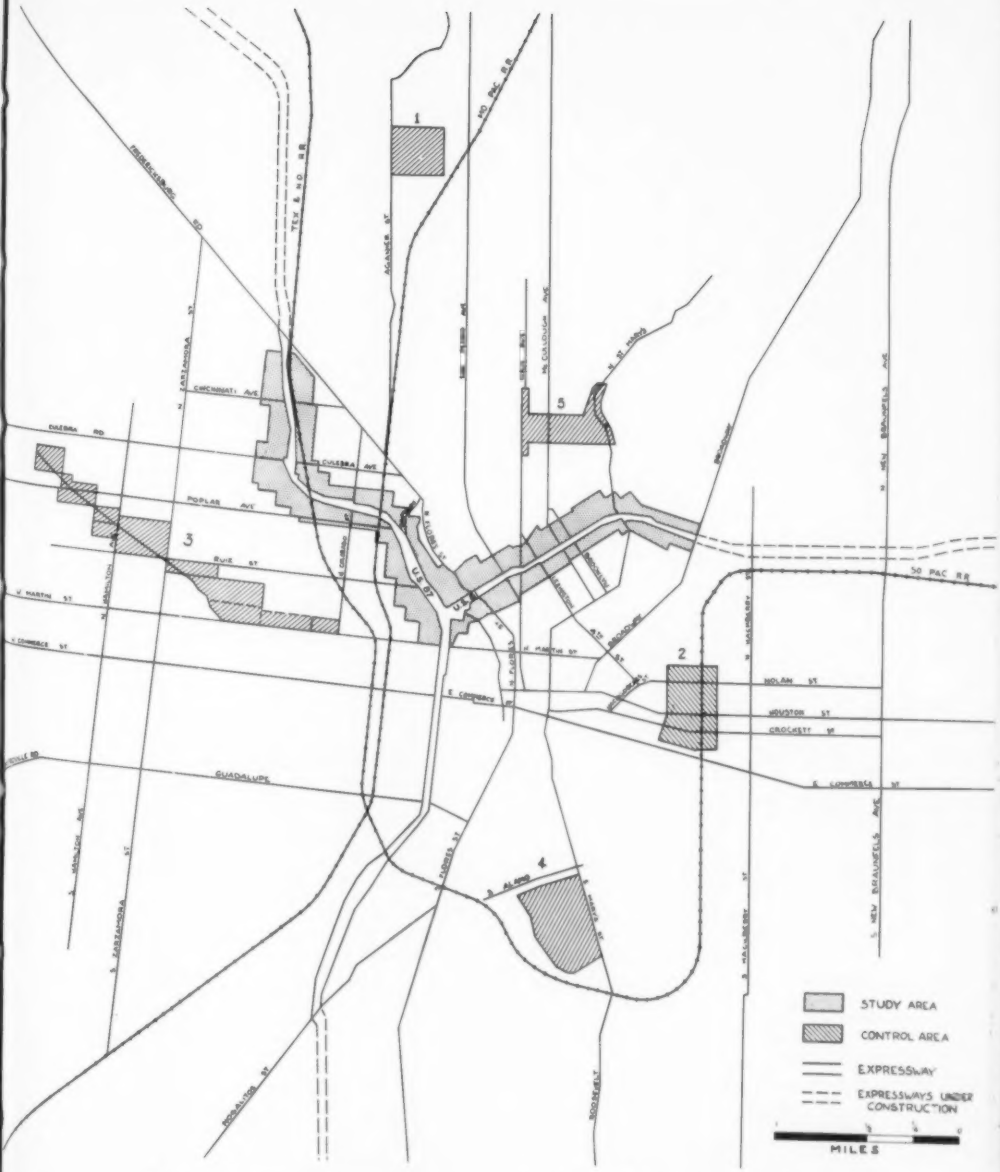
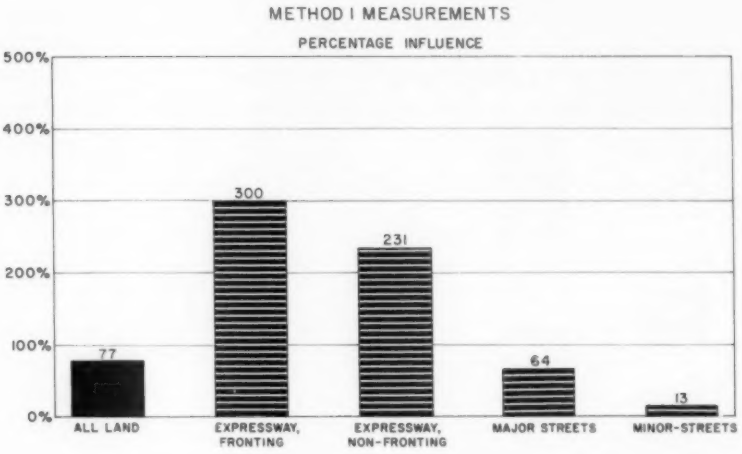


Figure 5. San Antonio Expressway Study and Control Areas.

Figure 6. The "Y" of the US 81 and US 87 Expressway sections near a part of San Antonio's Central Business District.

SAN ANTONIO
EXPRESSWAY INFLUENCE ON VALUES
OF ADJACENT LANDS
BY TYPE-OF-STREET LOCATIONS



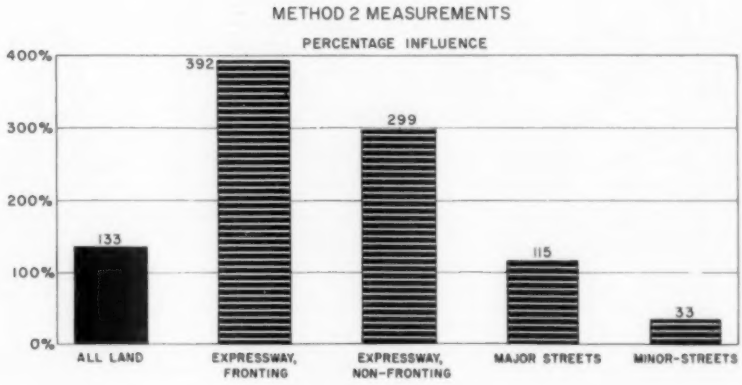
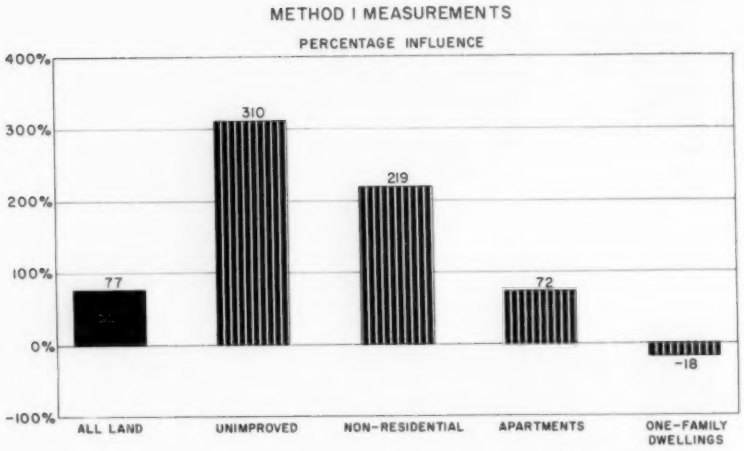


Figure 7.

SAN ANTONIO
EXPRESSWAY INFLUENCE ON VALUES
OF ADJACENT LANDS
BY LAND USES



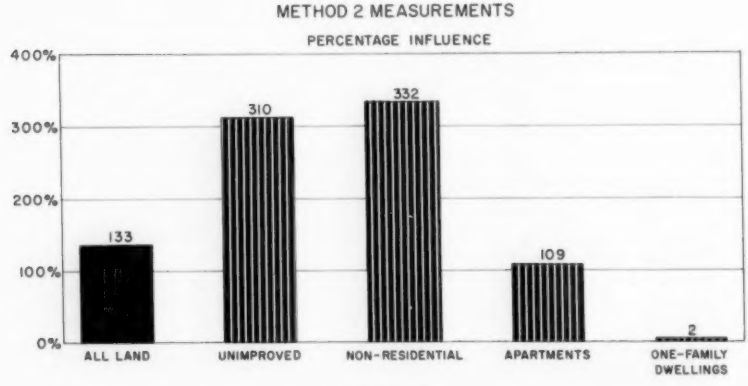


Figure 8.

Measurements of the effect of an expressway on the over-all study area are, of course, fairly general in nature. Many types of properties with different accessibility are combined in such indexes of influence. Yet, it is of some value to know the character of the summarized influences. As presented in Table I, the rather narrow tier of abutting properties, *A Band*, was enhanced spectacularly by Central Expressway over the 1941–45 to 1951–55 study period. Method I results, which comprise untreated sales prices, show that *A Band* property values were benefited by 271 percent. The value of land only as reflected by Method II rose 483 percent. This latter figure, as an example, was obtained by subtracting the 140 percent gain in value in the band's control area from the 623 percent rise in values in the study area.

Table I

CHANGES IN LAND VALUES ALONG DALLAS' NORTH CENTRAL EXPRESSWAY AND IN CONTROL AREAS

(Base = 1941–45 Prices)

	Method I			*Method II*		
	Unadjusted Real Estate Prices			*Value of Land Only*		
	Percentage Change		*Inferred*	*Percentage Change*		*Inferred*
	Study Area	*Control Area*	*Expressway Influence*	*Study Area*	*Control Area*	*Expressway Influence*
Ten-Year Period	%	%	%	%	%	%
A Band	405	134	271	623	140	483
B Band	110	132	−22	123	123	0
C Band	231	121	110	185	127	58
First Five-Year Period						
A Band	8	95	−87	56	136	−80
B Band	48	92	−44	58	122	−64
C Band	95	88	7	97	123	−26
Second Five-Year Period						
A Band	397	39	358	567	4	563
B Band	62	40	22	65	1	64
C Band	136	33	103	88	4	84

Strangely, the measurement scheme failed to yield expressway benefits in *B Band* over the full study period. In fact the Method I estimate was that second-band property values lost a net of 22 percent. (Real estate prices in the *B Band* study area rose 110 percent but the increase in the control group was 132 percent.)

The expected pattern was that the expressway's impact would diminish as distance from the facility increased. *C Band*, however, was shown to have been enhanced, this in contrast to the experience of *B Band*. For *C Band* the Method I and Method II estimates were 110 and 58 percent respectively. Certainly, such a departure from the hypothesized influence deserves careful attention. Did the beneficial influence of Central Expressway on land values indeed leapfrog from abutting land to a third band of properties, or did the study scheme fail as expressway benefits decreased with distance? As will be discussed later, both of these explanations seem to have some merit.

To continue the inquiry, Table I also shows that negative measurements were obtained for all three bands during the first five-year period (1941–45 to 1946–50). *A Band*, according to these calculations, incurred the greatest damage among the three study areas. *B Band* also failed to increase in value as rapidly as its control area. Method II measurements showed that *C Band* esperienced a 26 percent net disbenefit but, in contrast, Method I showed a small positive influence in the area.

Several interesting factors help to explain the indexes of negative influence. Admittedly, Central Expressway well may have had detrimental effects on land values during the early years of its construction, that is, during 1946–50. Interviews revealed that considerable uncertainty existed as to what effects the new expressway was likely to have. It is unlikely, however, that this uncertainty would have reached three to five blocks into *C Band*. A greater likelihood was that the control areas for all bands provided too rigorous a test for study areas. This is to say that control areas had a greater potential for higher values than did study areas, which fact accounted for a sizeable portion of the negative character of the measurements of influence. Evidence was found in the study to support this conclusion.

Another important factor was that properties which sold in study and control areas did not represent precisely all properties that existed in the areas. Furthermore, the lack of representativeness introduced a bias to reduce the indicators of Central Expressway's land-value impact. As an example, in *A* and *B Bands* poorer-than-average properties sold during 1946–50 and 1951–55, while better-than-average properties sold in 1941–45. The result, of course,

was that underestimates of land-value impact were obtained for the two bands. *C Band* and the several control areas showed far smaller discrepancies in representativeness.

Referring again to Table I, it is important to note that in the second five-year period (1946–50 to 1951–55) all bands were calculated to have received significant positive benefits. Again, *A Band* values rose spectacularly. *C Band* outgained *B Band* but not so much as for the full ten-year period.

Table II

CHANGES IN VALUES OF UNIMPROVED LAND
ALONG DALLAS' NORTH CENTRAL EXPRESSWAY AND IN CONTROL AREAS
(Base = 1941–45 Prices)

	Percentage Change		*Inferred*
	Study Area	*Control Area*	*Expressway Influence*
Ten-Year Period	%	%	%
A Band	518	150	368
B Band	383	162	221
C Band	291	186	105
First Five-Year Period			
A Band	42	60	−18
B Band	85	70	15
C Band	58	86	−28
Second Five-Year Period			
A Band	476	90	386
B Band	278	92	206
C Band	233	100	133

Table II presents findings of Central Expressway's impact on the value of unimproved land. The negative influence measured for the first five-year period is subject to the limitations already named. During the second five-year period and over the full ten-year period, however, the expected pattern of influence was revealed. Unimproved land in *A Band* was benefited 368 percent; in *B Band* 221 percent, and in *C Band* 105 percent, from 1941–45 to 1951–55.

A great deal of additional analysis of the Central Expressway study is reported in the publication cited earlier in this article. Only a few further observations may be made here.

Table III

CHANGES IN TAX VALUATIONS
ALONG CENTRAL EXPRESSWAY AND IN CONTROL AREAS
1945 TO 1955

	Percentage Change		*Inferred*
	Study Area	*Control Area*	*Expressway Influence*
Tax Valuations of Land	%	%	%
A Band	344	40	304
B Band	83	41	42
C Band	51	33	18
Tax Valuations of Improvements			
A Band	780	42	738
B Band	104	46	58
C Band	47	35	12

It was found that the tax valuations of land and improvements rose significantly more in *A Band's* study area than in its control area (Table III). The differential for land was 304 percent from 1945 to 1955 and for improvements, 738 percent. In *B Band*, tax valuations of land were found to have been increased by 42 percent, and valuations of improvements by 58 percent. The net influence of the road improvement on tax valuations in *C Band* was 18 percent for land and 12 percent for improvements. The data relating to the value of improvements comprise good measures of the aggregate change in land use in each band.

North Central Expressway was located through an area of many different property types, ranging from an old neighborhood of substandard housing to a small industrial section. Close attention was given in the study to the expressway's influence upon the various sub-areas. Generally, the findings were similar to those summarized above. The dominant factors that conditioned the facility's impact were proximity, amount of unimproved land, zoning, and previous value of buildings. As will be seen, these factors were given primary attention in the San Antonio expressway study.

San Antonio Study

San Antonio is Texas' third largest city, trailing only Houston and Dallas in population. Its metropolitan area grew from about 500,000 population in 1950 to more than 700,000 in 1957 and

continues to increase briskly. Like Dallas, San Antonio is primarily a trade center. Military establishments make up a vital part of its economic base. Medical services and tourist trade are important but manufacturing accounts for only twelve percent of the city's gainful employment.

Although San Antonio's rate of growth has been comparable to that of Dallas, it has not appeared to be so spectacular in nature. Yet by the most usual means of measuring a city's progress, San Antonio provides a dynamic setting for urban expressways and an opportunity for testing their economic impact.

Figure 5 shows schematically the study and control areas used in the San Antonio study. The subject expressway comprised sections of U. S. 81 and U. S. 87, and totaled 3.7 miles in length. For most purposes of the analysis the two sections were treated as one facility and are labeled as such in this article. For the most part, the expressway has four freeway lanes separated in pairs by a median. A very short section has six through-lanes. Frontage roads are provided intermittently for about 32 percent of abutting land. This design-feature was one reason that the expressway was selected for study.

Real estate prices, analyzed by the same methods used in the Dallas study, were used to reflect land-value impact. No attempt was made to analyze tax valuations as such. Another departure from the Dallas study scheme was that the study area was not divided into bands. Instead, properties that sold were classified as to location, land use and zoning. This categorizing allowed measurements of the expressway's impact on abutting land, designated as *A Band* in the Dallas study. Otherwise, findings from the two studies are not directly comparable.

The San Antonio study area was about equal in width to Dallas' *A* and *B Bands* combined—two to three blocks on each side of the expressway. An additional two blocks among major intersecting thoroughfares were included. Five areas in other parts of San Antonio were used as controls for the study areas.

The "before" period in the study was 1941–45, in view of the fact that definite planning for the facility was begun in 1946. Construction was started in 1947 on a limited scale. The "after" period was chosen as 1952–56; no analysis was made of sales occurring in the middle 1946–51 period. Since the expressway was not

complete until 1954 and was then still a part of an incomplete expressway system, the findings must be considered tentative.

The results of the land-value impact calculations are summarized in Table IV. The net influence of the expressway on the entire study area was shown to be 77 percent by Method I and 133 percent by Method II measurements. There was a great deal of variation in the benefits experienced by the several property-types studied.

Table IV

CHANGES IN LAND VALUES ALONG SAN ANTONIO'S U. S. 81 AND U. S. 87 EXPRESSWAYS AND IN CONTROL AREAS, BY LOCATION CHARACTERISTICS, LAND USES AND ZONING 1941–45 TO 1952–56

	Method I			*Method II*		
	Unadjusted Real Estate Prices			*Value of Land Only*		
	Percentage Change		*Inferred*	*Percentage Change*		*Inferred*
	Study Area	*Control Area*	*Expressway Influence*	*Study Area*	*Control Area*	*Expressway Influence*
	%	%	%	%	%	%
All Land	164	87	77	200	67	133
Land at Various Locations:						
Fronting Expressway	387	87	300	460	68	392
Abutting Expressway, Not Fronting	318	87	231	367	68	299
Major Thoroughfares	133	69	64	198	83	115
Minor Streets	106	93	13	99	66	33
Land Use Types:						
Unimproved	393	83	310	393	83	310
Nonresidential	208	−11	219	348	16	332
Apartment	141	69	72	175	66	109
One-Family Dwelling	68	86	−18	59	57	2
Zoning Districts:						
Manufacturing	232	24	208	218	19	199
Retail and Commercial	182	91	91	227	96	131
Apartment	117	96	21	187	74	113
One-Family Dwelling	97	107	−10	72	77	−5

The second portion of Table IV indicates that the greatest enhancements occurred for properties with frontage road locations. The average influence was estimated as 300 percent by Method I and 392 percent by Method II. Other abutting properties also registered sizeable benefits, 231 percent under Method I and 299 percent by Method II. Locations on major thoroughfares expe-

rienced smaller but significant benefits, and properties on minor streets demonstrated very small effects.

These findings, although they are not proof of the full economic justification for frontage roads, they do support the belief that the pattern of economic impact is affected by the presence or absence of frontage roads. In addition to the controversy regarding design, there yet remains the question of just what economic impact may be desirable. The Dallas and San Antonio studies should be of aid in predicting the influence of expressways with various design features, although certainly they do not set forth an ideal model of economic impact.

Land use appeared to be another important factor in the expressway's impact. As along the Dallas expressway, unimproved land received substantial benefits as did nonresidential properties (Table IV). Unimproved land was enhanced 310 percent and the retail, commercial and manufacturing group reflected a net influence of 219 percent according to Method I, and 332 percent by Method II calculations. Land in apartments was raised in value by 72 percent, Method I, and 109 percent, Method II. Single-family dwellings as a group, however, showed little if any favorable effects. In fact, Method I indicates that this class of property was damaged. The index of damage, eighteen percent, is not large and Method II, in effect, shows that dwellings were little affected.

There is reason to believe, however, that the value of a few dwellings was depressed, since the value of some dwellings with frontage road locations was enhanced considerably. It is likely that any actual disbenefits accrued to residences on dead-end streets, near elevated expressway sections and in residential zoning districts. The calculated influence of this latter factor is summarized in the final portion of Table IV.

Zoning appeared to have much the same relationship with the expressway's influence as did land use. Land zoned for manufacturing received the outstanding benefits. Retail and commercial and apartment zoning districts also showed significant increases. One-family dwelling districts experienced small negative effects according to both measurements. The fact that this class of property has little opportunity for changes in use is a natural limitation to benefits from an expressway.

The San Antonio expressway, like Dallas' Central Expressway, transversed an assortment of land uses. These included a blighted residential area, two manufacturing districts, several small shopping districts and a subdivision of middle class dwellings. Some valuable slum clearance was accomplished in Dallas and San Antonio, and in both cities the expressways were instrumental in alleviating drainage, air and lighting problems. Certainly, these factors tended to enhance property values. At the same time, noise, fumes, neighborhood severance, and other nuisances often attributable to expressways were present as depressive factors.

The most important effect of each expressway, however, was the betterment of access of adjacent properties to the central cities and to other points in the urban area. Certainly all classes of property may be enhanced by improved situs; that is, by being placed relatively closer to a variety of other locations. The concept of transferred vehicular benefits may be applied appropriately here. To the extent that total transport costs for a parcel of land are reduced, potentials for a rise in site value are increased. Present land values will increase with the enhanced probabilities of larger land income at some future time.

That land may be enhanced in value without a simultaneous change in its use is fairly obvious. In the first place, a site in a particular use can be made a better site for that same use. For example, a residential site may be enhanced by improved transportation facilities even though the house upon it is not changed in character. In the second place, increased possibilities for a higher use may be capitalized into land value although the actual change in use may be delayed for a number of reasons. This is to say that although an expressway ripens land for higher uses, time is required to overcome costs of supersession and other obstacles such as deed restrictions or zoning. In the meanwhile, the land will remain in the old use.

The expressways in Dallas and San Antonio illustrated these principles in that they improved in its old uses some land with little chance of use-change, and ripened other land for new uses at some future date. This fact helps to explain why land-use change

lagged behind land-value enhancements to a considerable degree. The lag in San Antonio was greater than that in Dallas. An important reason for this was that the Dallas study area contained the larger proportion of unimproved land. When the cost of removing old buildings and the income stream of the old use do not have to be exceeded by site rent in a new use, a major barrier to use-supersession is avoided.

It sometimes is contended that the use of land and its value are substantially expressions of the same thing—the intrinsic worth of land as a contributor to production. This is true only if the value of land is considered an expression of its present and also its potential use. Land use and land value are not synonymous, nor do they necessarily succeed each other in a circular manner. More correctly, land use tends to confirm or deny the accuracy of previous land-value judgments, whereas present land value confirms or denies the accuracy of previous decisions as to highest and best use. It is this complex that makes economic-impact research an inexact but challenging area of inquiry.

The Dallas and San Antonio studies were focused upon land-use and land-value impacts on adjacent land. Some effort was expended in explaining the manner in which changes occurred. Generally, however, the two studies are weak in the latter regard. Also, they have some very real limitations in their methodology. The resultant measurements are lacking in precision. These same faults may be attributed to many other impact studies that have been conducted. A continuing effort to broaden the scope, increase the depth and precision, and relate the findings to various other factors, such as traffic, is needed to make economic-impact research fulfill its functions in a more acceptable fashion.

Freeways Alone Are Not Enough

SEYMOUR S. TAYLOR

Mr. Taylor has been General Manager of the Department of Traffic for the City of Los Angeles since January 1, 1958. Previously, he was for two years Assistant General Manager of the Department. In 1938, he became the first traffic engineer for Salt Lake City, Utah on a consulting basis and for fourteen years served that city and other intermountain cities and governmental jurisdictions as a traffic engineering consultant. During this period he was also affiliated with the Galigher firm of engineers as a design engineer and general sales manager. Mr. Taylor worked for many years with automobile and insurance companies on analysis of "Speed and Accidents," the subject of his national award-winning thesis in 1938. In 1952, Mr. Taylor was appointed first full-time professional City Traffic engineer for Salt Lake City. He was selected in 1955 as Senior Traffic Engineer in charge of operations of the Los Angeles Department of Traffic. Mr. Taylor is a Registered Professional Engineer, a member of the Institute of Traffic Engineers, and has been a member of the American Society of Civil Engineers, the Highway Research Board and other professional groups.

INCREASED urbanization is the trend of our times, and the greatest socio-economic problems are found in urban areas where land use and access are key factors in community progress. Steps of great magnitude must be taken so that urban centers will continue to thrive and expand.

Huge programs of expressway and freeway development and urban redevelopment for metropolitan areas within the next ten to twenty years are inevitable. These programs, which will cause revolutionary changes in the city structure, must be based on integrated planning of transportation facilities and of land use to best solve the over-all metropolitan area problem.

The concepts of city planning and of traffic engineering are based on different criteria, although the objectives of both functions are the same. City planning is broadly concerned with land use and control, and its regulation of densities and establishment of industrial, commercial and residential districts affect the generation of

traffic movement; while traffic engineering is the planning, design, and operation of the streets and highways required to accommodate traffic movement and provide land access. Both traffic engineering and planning are dedicated to the optimum utilization and conservation of community resources, the preservation of amenity, and the wise development of regional values.

Highway engineers utilizing urban traffic knowledge and cognizance must team with city traffic engineers, city planners, transit officials, architects, and economists to effect adequate urban transportation facilities.

Much more thought must be given to the proper positioning and site-location of traffic and parking generators. Heretofore, many architects have extracted large fees without providing traffic engineering analyses. Lacking these analyses, abnormal traffic burdens have been imposed and many investments threatened, if not lost.

Traffic engineers in both governmental and private agencies must be used by the architects and planners as partners and not just as after-thoughts if the citizens, investors, and public officials are to benefit as they should. Site consideration, ingress, egress, generation characteristics, and traffic and parking specialized study and design are most essential. Experts in this field should be consulted.

I believe the architects and planners will do well to recognize their own limitations in the traffic and parking field and accept on an equal professional level the valuable assistance of the traffic engineer.

Role of City Traffic Engineers

Any city can have the degree of traffic improvement it is willing to work and pay for—yet it cannot afford to spend unwisely a single dollar for traffic.

There are few things today that are more important to the welfare of the modern community than good traffic engineering. It is right up there with medicine and education as a factor in the everyday life of every citizen.

Important today, it will be even more important tomorrow. Our nation will more and more be one of urban dwellers. Our cities have been growing in area as well as population. This spread-out may be attributed to revolutionary advances in technology over

the past several years. Top billing must be given to the motor vehicle among other powerful technological partners.

Other than knowing that they have to dig down into their tax pockets to pay the salaries and costs of traffic engineering, and that they have some responsibility for that new road coming right through their living rooms, citizens generally know little of what traffic engineering is and does.

Unfortunately, the traffic engineering of today is tagged with all the past politically-placed traffic signals and stop signs, and inherits as well all the problems of inadequate or deterrent street and structure widths, alignments, grades and insufficient capacities of streets and highways.

The relatively new profession of traffic engineering has evolved with the advent of the motor vehicle and the rapid and drastic change in the historic problem of traffic control wrought by this device of the twentieth century.

Traffic Accidents

For many years the engineers' work was assumed to be finished with the completion of the roadway construction. But the motor vehicle complexities, involving ever-increasing speeds, conflicts, and volumes, created problems beyond the scope of historic methods of police control and regulation. Consequently, the engineer has been called in to apply his science to the problem. Actually only the last decade has witnessed the adulthood of traffic engineering.

Good government public relations is good performance— publicly appreciated. Government must first do a job that people can think well of, and then intelligently and deftly call attention to it. Governmental traffic engineering has a formidable assignment in working to achieve safe, convenient and economic transportation of its citizenry and the goods they need and produce. This cannot be a one-man, a one-organization, or a one-profession accomplishment. But traffic engineers must lead and stimulate the work if it is to be successful. They must excite enough official and public opinion behind the problem so that corrective plans are effective when adopted.

I am convinced that we cannot entirely eliminate traffic accidents without eliminating traffic itself and the motor vehicles, people, and roads that comprise it. I am further convinced that

there is a level of traffic accidents that is a necessary concomitant of things of greater value to society.

To really achieve a national "No Traffic Death Day" we would just have to stop traffic for twenty-four hours.

An average of one hundred people die in traffic each day in our country (approximately two-and-a-half percent of the total who die from all causes of death).

In the City of Los Angeles, an average of one person per day is killed in traffic and there is a reported traffic accident in our great city every ten minutes on an average, day in and day out. However, from these facts we can at least gain the perspective that traffic is not yet exterminating us, so we can afford to approach the problem calmly.

The quantity of kinetic energy loose on our roads—taking into account the increased numbers, weights, and speeds—is at least ten times what it was twenty years ago when I, to join a handful of others, entered the neophyte profession of traffic engineering. Yet it is a significant fact that the daily traffic death rate has remained fairly constant at about twenty-five deaths a year per 100,000 of population over this same period.

The dominant factor has been the improvement in the physical equipment. There have been improvements in motor vehicles, but the most important improvement has been in roads and traffic management.

The important thing about traffic and the motor vehicle is not that they kill in our country one hundred people a day, but rather that they have comprised a crucial factor in the development of a fantastically complex and rich society.

The motor vehicle has given us a new degree of personal mobility that we have exploited to develop the industrial complex, to provide ourselves with agreeable homes, a social life rich in choices, and a new degree of personal safety from the hazards of life.

While we move great loads of goods and people by traffic, the vehicle most characteristic is one that contains one person bent on a personal mission. If speed and convenience were not critical factors, this vehicle could be replaced completely and literally by a horse. However, our physical and social structure would be almost frozen in its present attitude were we to freeze the over-all speed of motor vehicles at unrealistic levels.

The question of when speed becomes too much is a very thorny question. I encounter situations where, I am certain, ten miles per hour is too much, and others where eighty miles per hour is not too much, and the variations in the situations are too great to be controlled very intelligently by fiat and in advance.

When is Speed "Too Much"?

We must somehow strike a balance between the promotion of traffic flow and the limitation of speed. While perhaps well-intentioned, many of our motor vehicle laws are inappropriate, as the letter of the law makes everyone a violator.

Generally speaking, I believe that drivers, as interested parties on the spot, have the intelligence and judgment, if not deadened by stimulants, to reckon with traffic situations.

I know also that one traffic experience strongly affects important decisions made elsewhere. There is a noticeable feeling of well-being when moving expeditiously, and one of intense irritation while sitting and staring at a red light—particularly when there is no opposing cross traffic.

The lawmaker who frames an unnecessarily inhibiting regulation or the local authority that installs unnecessary ill-timed traffic signals or unwarranted stop signs inadvertently imposes a loss on society. A misformulation of the problem may lead to solutions that do more harm than good.

Unwarranted Controls

The central problem is to promote the smooth and rapid flow of lots of traffic with reasonable safety.

The traffic light is a useful device to promote the flow of cross traffic when the traffic density on two streets is at a certain level, but it is not the best device for all levels of density and for all purposes. It has been used, and continues to be used in some areas, for purposes deliberately inimicable to traffic flow. The traffic engineer is professionally dedicated to the collection and junking of unnecessary traffic signals and stop signs as well as the placement of needed ones. Unfortunately, sometimes the political pressures outweigh the professional strength, though in our city the past is the chief gremlin in this respect.

The high emotional content and insufficient reflection of the ritual around school zones appear to be oblivious of the fact that school children in fixed groups and under supervision are safer on the school grounds than at any other time in their waking lives.

School Zones

The Los Angeles safe route program, with crossing guards and buses teamed with traffic controls applicable *only* during their transit hours between home and school, protect children during this concentrated exposure period. The danger lies in possible overprotection during these school hours with little or no supervision and cautionary measures at other times, at other places. No one can be protected against his own carelessness.

Traffic Safety Lighting

Traffic-safety street lighting has yet to grow up in Los Angeles because archaic methods of financing still exist. Maintenance of street lighting is financed usually by abutting property owners, who frequently and properly refuse to pay the whole bill for traffic features of major benefit to the passing traffic. On the majority of arterials, traffic has no interest in abutting property along the way, but it does want and need adequate light on the pavement and in its proximity.

It is often said that a community gets the kind of traffic improvement it wants. This is a rather loose statement, for there is no way in which the long-suffering street-users can register daily their demand for traffic improvements they desire.

"Squeaking Wheel" Minority

The "squeaking wheel" minority certainly cannot be the only determining factor. Certainly, the economic well-being of our great city is closely tied in with its traffic circulation. Must we not look to motivation which stems from economic gain as the fundamental motive in traffic improvement? The enlightenment of the "selfish interests"—what is good for the public is also good for them—seems to be indicated so that these forces may be harnessed in gaining a common objective.

Proved controls and methods must be uniformly applied, with facts forming the foundation for all standards and policies. Facts should determine: Ways to make the most efficient use of today's facilities; location and design of new facilities; needs and methods of attack on the parking problem, and needs of rapid transit. Again, only through facts can divergent views be reconciled. Facts are necessary to obtain public understanding and support and to answer complaints and pressures.

Facts Required

In Los Angeles, many special and costly studies (forty-nine of them) have been completed and filed. Only a few have resulted in activated programs. Some studies have pointed to the absence of factual data upon which to base sound recommendations for future traffic needs. These studies have only looked at part of the traffic problem—mostly transit.

Accumulation of facts is not enough. To be useful, the facts must be analyzed, interpreted, and applied by competent, skillful, painstaking personnel. The work must be a continuing function of the city. Area-wide studies must be made and applied.

No comprehensive area-wide traffic study has ever been made in the Los Angeles area.

This should be a combined effort of all jurisdictions and agencies in the vast Los Angeles metropolitan area.

These studies reveal such things as the volume, origin and destination of traffic, purpose of trip, the proportion of traffic forced to use various arteries because of the absence of better ones, and the "desire lines of travel" which simply mean the routes drivers would prefer to travel.

Such a study in metropolitan Los Angeles would give accurate measures for answering many problems. Determination of the desire lines of travel would throw a powerful searchlight on the needed traffic improvement of ordinary streets and of designation of freeways and their interchanges and entrance and exit ramps. Accurate knowledge would be obtained of the proportion of traffic to be attracted by good rapid transit. Establishment of truck routes and determination of over-all parking needs are other almost priceless benefits. This would not in any way interfere with the progress

of the current freeway program. Later portions of the freeway program, on which no binding commitments have been made, properly should be reviewed with regard to the developed facts, and whatever changes appear practical and reasonable should be incorporated in plans of the future.

A special parking study with evaluation of parking needs and trends is essential to private enterprise and to the city, whether undertaken singly or in co-operation. Today's needs and tomorrow's are such that a factual summation of them might well jar private business and the city into action.

Urban "Mobilitis"

Full advantage has not been taken of the story that accidents tell. There is real need for engineering analysis and engineering treatment of high-accident locations. Accident reductions may be achieved easily and cheaply by a study of the causes.

Speed and delay studies using special vehicles and instrumentation are evaluating how well traffic is moving throughout the city. This can be a factual basis for establishing priorities of improvement.

We must know how much traffic there is and where it flows. Cumbersome, time-consuming counting methods are giving way to instrumentation and data processing.

Co-ordination with enforcement, planning and transit in our city must be continually improved and strengthened if traffic engineering is to do its job well. Integrated efforts of city, county, state, and federal agencies must be accelerated.

Metropolitan Los Angeles is afflicted with "urban mobilitis." An expanding urban population which travels increasingly on wheels is the symptom.

Exploding population increases, pyramiding vehicle-registrations, and extended usage have resulted in many more miles-per-vehicle threatening to clot our traffic arteries with parked vehicles and motorists hunting a place to park.

The inability of our present streets and parking facilities to continue to carry this ever-increasing transportation load threatens to choke off the economic breath of our metropolitan area. Meanwhile, its vehicle-exhaust fumes aggravate the breathing citizenry under a unique atmospheric inversion.

Los Angeles today possesses the basic ingredients of the pattern of the modern metropolitan area dependent primarily upon vehicular transport.

More wheeled traffic moves in Los Angeles than in any other city in the world. We have thrived on rubber tires, self-starters and other developments that have made the wheeled vehicle our most useful device.

Los Angeles is a city of magnificent distances. Consequently, free-flowing traffic is vital. Streets are the arteries and capillaries that feed the city, occupying a position comparable to the water trunks, mains, and lead-in lines that supply factory, store and home. Clogged traffic routes are as damaging as pipes from which there is only a trickle of water.

Foresight, planning, and fortitude are necessary as transportation literally molds the shape and growth of cities. As the nucleus of a lusty, growing metropolitan area, Los Angeles must consider not only her own growth and her own needs, but also the effects brought by changes on the commerce and population of the entire surrounding surburbia.

The people of the City of Los Angeles have a sizeable investment in their transportation plant. The right-of-way values, street expenditures, and rolling stock values involve a total well in excess of six billion dollars. Yet without this investment the city would be literally paralyzed.

Not only does the Los Angeles region have more vehicles on a population basis, but they are used more than in any other area in the world.

Causes of traffic congestion in our area may be summed up as follows:

1. Exploding growth and skyrocketing vehicle volumes
2. Climatic and other conditions encouraging street usage
3. Scattered generators of traffic
4. Absence of complete system of traffic facilities
5. Improper use of existing facilities
6. Irregularities in street pattern
7. Limited capacity of street intersections
8. Promiscuous mixing of all types of traffic
9. Natural and artificial obstructions to circulation
10. Lack of adequate off-street parking facilities.

Parking in Los Angeles has been a neglected urchin of the streets and off-street parking facilities have come and gone.

Lack of parking hampers the city and its people in many ways. Failure to provide parking in a business area is to deny access to motor-vehicle users. Insufficient facilities cause cruising and further clogging of streets. The result is high parking charges, delays, long walks to destinations. Like congestion, inadequate facilities work to alter the desired pattern of city development.

Streets, Terminals and Transit

The importance of planned action is emphasized by the fact that the efficiency of the street and freeway system, the volume of sales in a district, and the amount of labor available for a district all rest on the ability of the terminal facilities to accommodate demands.

If intelligent control and regulation of traffic are to be achieved, the make-up of the traffic stream itself must be evaluated and related to regulation, control and enforcement measures.

Automotive traffic is composed of passenger cars with ever-increasing variation in size and operating characteristics, trucks of all sizes, motorcycles and scooters, etc. Transit vehicles of several types, trolley coaches, street cars and buses intermingle with this heterogeneous mixture and then the pedestrian is added for further complexity.

The private motor car does not represent the whole traffic problem. Our trucks and other commercial vehicles play a vital role in our economy also. However, we still need mass transit to meet travel demands. Mass transit can and should operate wherever desired lines of mass movement exist. It is highly impractical to depend upon the passenger car, with its average occupancy of 1.6 persons, to move thousands of people from the same general origin to the same general destination. Where movements are scattered, irregular, or relatively few, it is, of course, impractical to operate mass transit unless large assembly and dispersal areas are developed.

The economic element, population, vehicle registration, land use, the street and freeway system, mass transit, parking, commercial loading and unloading, operating elements and the social element—each has an important bearing on traffic engineering

decisions and programming. To cope with these interrelated elements, traffic administration must be full-fledged and geared to the development and use of facts. Traffic administration must possess authority and standing not only to conduct its routine operations, but to carry on the leadership and guidance which traffic administration must assume if the elements of the traffic problem are to be brought into proper focus.

Land-Use Crisis

Proper land use in metropolitan areas is critical. Land use comprises persons and machines doing things involving activities.

The dominant items in transportation are persons and vehicles in motion. So transportation and land use are inseparable, both being parts of the same thing—human activity in urban areas.

Service to moving vehicles must be balanced with service to the semi-static activities taking place on the land.

This requires a total traffic circulation system with freeways balanced with the capacity of the surface street system.

Freeways will only help, not entirely solve, the urban transportation problem. Excess freeway design capacity may cause inefficient interchange, and bottleneck the arterial street system.

It would not be feasible to provide sufficient traffic lanes in some sections of the freeway system to satisfy the traffic volumes that the next twenty-odd years will assign to them.

Total Traffic Circulation Needs

The excess traffic in 1980—which must be carried by the surface street system or mass transit system—is estimated as greater than the total present-day volumes. Therefore, in 1980, metropolitan Los Angeles, even with approximately 900 miles of anticipated freeways and 300 miles of expressways in operation, may well have worse traffic conditions than exist today—unless we provide relief beyond the freeways.

Highway planners and builders are the chief makers and breakers of cities, for what is a highway apart from its terminal? Every freeway trip has its origin and destination on a surface street. No circulatory system is possible without a heart to pump

Los Angeles, a city of 'square colossal blocks', may ultimately have a freeway network.

it; damage one and you damage the other. Change the nature of one radically, and you change the other one also.

Highway decisions have profound implications for land use throughout the metropolitan area, and perhaps for the financial stability of the city's entire core.

From the point of view of between-city or into-city traffic, the entire urban metropolitan network is a terminal system that collects and distributes the long-distance traffic and provides it with terminal facilities. Within large cities like Los Angeles, the other function of the urban freeway and street network—facilitating movement among parts of the metropolitan area itself—is much more important because of the volume of traffic. The needs of both kinds of traffic must be taken into account.

Land-Area Ratios

A local transportation system, including its highway and street network, is essentially a service system, the function of which is to expedite the daily business of a community through reduction of "the friction of space." The capacity of that system may place an ultimate limit on the size of a city's population and the area over which it may spread.

Good urban traffic management consists of:

1. Regulation and control of traffic.
2. Provision and improvement of physical channels of movement.
3. Planning, guidance, and control of change in the pattern of land uses.

This question of land use is critical, for already approximately twenty-eight percent of the land area comprising downtown Los Angeles, for example, is in streets, freeways, and service ways and another thirty-eight percent is in the off-street vehicular parking and loading, so about two-thirds of the land is primarily devoted to rubber.

One freeway interchange in Los Angeles is consuming approximately eighty acres of land area, and each average mile of freeway is requiring about thirty acres.

One-third or more of our entire Los Angeles urban land area is already required for transportation facilities.

Ultimately, it appears that Los Angeles will have a freeway

network forming a city of square colossal blocks where topography will allow them, with approximately four miles of freeway on each side. Within these sixteen-square-mile areas, and unifying them, an integrated transportation system must operate or they will plow under the goose that lays the golden egg, destroying the city they were meant to serve, its productivity, and the traffic revenues therefrom.

Terminal Facilities

Freeways, coming through a city like mighty rivers, must branch smoothly off into specialized smaller streams; but it is the clogging at the entrances and exits that threatens these great arteries which cost the taxpayers many millions, and yet they deliver the traffic into a 19th-century surface street system.

Parking must no longer be treated as a step-child.

A freeway system without parking is like a railroad without a station. A vehicle that cannot be left and picked up again is virtually useless. In the last analysis the automobile has only one destination: a parking space, either at the curb or in an off-street facility.

The traffic-capacity of the freeway or local street, while usually determined as a function of the traffic demand, is actually dependent upon the capacity and accessibility of parking spaces in the metropolitan terminal areas.

Excess capacity of freeways leading in frequently results in excess congestion on city streets where curbs are lined with parked cars. For the state, which builds the freeways and expressways, to say that the off-street parking problem is a local concern is to avoid the issue. The capacity of the metropolitan radial highway system must reflect not only the apparent traffic demand but also the actual and prospective supply of parking facilities. And the supply and location of parking facilities must in turn be related to the comprehensive land-use and circulation plan for the area.

Service Facilities

The major contributions to downtown rehabilitation have been, and will continue to be, those proposals in which revitalized land use, parking and traffic-way access are elements of a single design.

Just as the railroad station, the trolley line, and the general purpose highway have, successively, been major determinants of

urban, and particularly commercial, development in the past, freeway and expressway interchanges and the service road are prime influences on the patterns now emerging.

Present policy insists that no service facilities of any sort shall be provided on units of the 90-10 interstate highway system—not even the gasoline and restaurant concessions so familiar on existing expressways and toll roads. This policy forces the traveler to leave the expressway or freeway at an interchange to find the necessary services, and these services have to be sought at one of the most congested and hazardous spots in our total system—the spot where high-speed free traffic is suddenly dumped onto ordinary streets and where local traffic is gathering to spew forth onto the freeway.

The traveler is forced to make at least one left-hand or cross-lane turning movement on a busy local street or highway, either leaving or entering the service facility. While this policy may slightly reduce the accident rate on the expressway or freeway, I doubt if it will reduce the over-all accident rate.

Properly designed occasional turn-offs to expressway service areas, with favorable topography and sight-lanes, might well reduce the accident rate now transferred to the surface street system by the "no service area" policy.

Mass Transportation

An important interrelationship exists between streets, freeways and mass transportation. These two systems should not exert uncoordinated competition for the taxpayer's dollar.

The solution of the commuter problem in large cities lies in discovering that complementary system of streets, freeways and transit lines which will most effectively promote and serve a truly functional pattern of land use.

Completion of the freeway-system loops will divert sufficient traffic from surface streets, in many instances, to also permit satisfactory surface street transit operations during peak periods.

Our only immediate practical means of improving or even maintaining the public transit service in Los Angeles is by operating express buses on the freeways and major thoroughfares.

A proposed transportation center is being co-ordinated with freeway planning to integrate all forms of transportation in central

Los Angeles—rail, inter-city bus, suburban express bus, local bus, convertiplane, and helicopter.

A proper freeway network will remove through-traffic from heavily-traveled business streets within the urban area's communities and result in substantial business gains. It sould be adjusted to the present and future social needs and economic welfare of the region and its separate parts.

Population Density

Expressways and freeways entering metropolitan districts have expanded single-family home areas on the suburban fringe. In the Los Angeles area, travel time—due to congested peaks—between work and peripheral homes, in many instances, is two hours a day. Consequently, there is a strong recent trend toward multiple housing. Last year the number of apartment units built in Los Angeles increased forty-one percent over the previous year while single-family homes declined thirty percent in the same period.

A population of five million—approximately one-and-one-half million households—living in our popular one-floor Los Angeles ranch houses built on average lots will need 500,000 acres for homesites alone, or more than a million acres to accommodate churches, schools, shopping centers and recreation units to serve them. This acreage is equivalent to 1,560 square miles just for residential area. This low density makes mass transportation uneconomic.

Traffic Pattern Changes

An area of 135 acres, on a 100-foot elevation above the Los Angeles plain and adjacent to downtown, is being considered for clearance of its obsolete structures. Office buildings, hotels, garages and tower apartments are proposed. Ample parking facilities, within the apartment buildings' proximity to the intersection of four major freeways and within easy walking distance to downtown offices and stores, make this plan most attractive to prospective tenants. This project will generate additional movements and tighten the traffic belt in that immediate area, but a well-integrated traffic plan is proposed.

Experience of the City of Los Angeles, as it relates to off-freeway changes brought about by the opening of new freeway facilities, involves several changes in traffic patterns.

1. A very marked reduction in the total volume of traffic results on the surface streets approximately parallel to and within one or two miles of the new freeway facilities.

2. In many instances, a 90-degree change in direction of major flow occurs on the adjacent city streets.

3. Because of the restrictions placed on cross movement, the traffic flow, normal to the freeway, is concentrated on fewer streets.

The change in traffic pattern makes it necessary to re-evaluate signal locations and timing. In many instances a change in regulatory measures controlling the street use is necessary, particularly with respect to parking.

There are also the problems created by the terminal and transition conditions of the freeway, as in most cases it is not possible to construct a freeway unit that completely crosses an area of major surface traffic, so that the opening of a section of a freeway produces a tremendous concentration volume at the terminal. It is necessary to use every available means of increasing the capacity of the streets leading to the freeway and delivering freeway traffic to the distribution system.

Alternate Routes and Guides Needed

There are also problems of taking care of the changing pattern as it relates to vehicles leaving the freeway. One of the things that has created some adverse criticism in the Los Angeles area is the fact that motorists are not given information as to their ultimate destinations after leaving the freeway because of congestion or closure. The recent state legislation, which permits the retention of the existing United States and State sign-route designation for the highways that have been superseded by the freeway construction, will tend to alleviate the problem. We are striving to work out an alternate emergency-route designation for local as well as through-traffic but our available geometrics are poor.

The problem of handling large traffic volumes that are now concentrated on a few streets has necessitated "No Stopping" restrictions in some locations, and in others the need for signalization on streets that will undoubtedly revert to more local usage upon completion of additional sections of freeway.

New freeways eliminate or obscure the common landmarks and

guides, with the higher operating speeds demanding faster decisions, and backlashing is common. Emergency diversions, as well as regular dispersions, force intrusion of busy traffic into residential and business areas particularly during the stages of construction.

As the freeways carry both trucks and passenger vehicles, interchanges—whether interim or permanent—create local problems of diverting truck traffic entering or leaving the freeways to routes that may adversely affect residential neighborhoods.

Access Rationing Required

The privilege of unlimited entrance to and exit from the freeways is uneconomical and serves only to add to congestion. Under existing arrangements a person may use a freeway for only a mile or two with consideration only for his own personal convenience.

Some flexible means of controlling the use of freeways and main arteries must be developed.

Some freeways are said to be outmoded before they are completed because they, too, become as congested as the routes they have supplemented. In some instances the traffic forecasts determining their design capacity have proved to be inadequate. This evidences need for broader vision and greater optimism for the future of our urban areas.

Surface Street Capacity Expansion Necessary

Even with the proposed completed freeway system, the majority of vehicle-miles of travel in the Los Angeles area will still be made on existing facilities and there is little opportunity to expand the mileage of our present streets.

Ultimate development of our existing street systems would include:

1. Eliminating all curb parking.
2. Restricting left turns unless separate left-turn controls and isolation can be achieved.
3. Providing separate lanes for bus stops.
4. Providing medians where street widths permit.
5. Eliminating unnecessary crossovers and separating opposing traffic flows.

6. Channelization as necessary.

7. Signal systematization with flexible traffic-adjusted control —radio-interconnected.

8. Physical separation of pedestrians and vehicles in concentrated areas.

9. Other improvements to eliminate traffic conflicts and interference.

Speed Comparisons

Speeds in Los Angeles, on loaded freeways and on major surface thoroughfares which have been developed to the ultimate, have almost identically the same peak-hour range, 25 to 30 mph.

The maximum theoretical capacity of approximately 2,300 passenger vehicles per lane per hour is developed between 30 and 35 miles per hour. Whether the lane under consideration is on a freeway, expressway, or city street makes little difference.

Balanced Traffic System

In the future in all metropolitan areas, more cars, buses, and trucks will be forced to use existing facilities, supplementing and supporting the new freeways. The contrast between the freedom encountered on the freeway and the frustrations of surface travel will be further accentuated.

Electronic control systems have been devised that measure traffic densities and can automatically control the speed and flow of traffic. These may well be used to route traffic for optimum facility use.

Parking structures integrated with freeways, and interchanges with automatic guidance to available spaces are being studied.

A proper ratio of mileage of freeways, arterials, and parking spaces must be determined.

Metropolitan areas must move quickly ahead and develop a comprehensive urban transportation plan, or our expressways and freeways will be built in an atmosphere of uncertainty and potential error.

The highway engineer must recognize the urban freeway as being but one element of the total urban street network and strive to achieve a balance and meshing of design that will assure efficient and safe operation of a co-ordinated system.

City officials must face up squarely to the responsibility of developing the remainder of the urban street network—the arterial, collector and local street systems—to those standards of design and operation that will assure the levels of service required to support the freeway system and prevent early obsolescence of the total transportation system and the urban area it is intended to support.

Are Facilities and Directions Understandable?

The well-worn phrase, "must be economically justified," has been sometimes overworked in avoiding the provision of adequate design—stopping short of doing the complete functional job and costing ultimately countless fortunes in money and taking many lives. A few dollars more may well guard the original investment. Considering the benefits obtained, a greater percentage of the cost of streets and freeways could be invested in better driver-aids such as delineators, vivid markings, large and frequent understandable signs, instrumentation, mechanical controls, and more adequate median separators.

More progress can be made in traffic safety—on all types of traffic ways—by emphasizing the relations between the driver, the signalling system, and the road, than by undue emphasis on a crash-proof car, which could lead us into the progressive stalemate analagous to the classic conflict between the projectile and armor plate.

We need to know more about traffic-accident causation. At the moment, the strongest statement we can make is that traffic accidents are caused by people, vehicles, and road situations.

Political Jurisdictions

Fortunately, federal and state highway officials are coming to concern themselves more and more with the urban traffic problems.

When you drive or ride in the Los Angeles metropolitan area you may cross one of a half dozen political boundaries. To motorists these are imaginary lines of which the existence is scarcely known.

But to traffic management officials these boundaries are very real indeed. They set limits on authority. These lines on the map determine where one set of law ends and another begins. They serve

to fix financial responsibility. These imaginary lines can loom up as real traffic barriers. They can be just as big and just as bothersome as we permit them to be.

We must gear our governmental organization to the automotive and freeway age, and our working relationships to realities. Traffic moves without regard to political boundaries; and traffic service, to be fully effective, must be on the same basis.

The Los Angeles metropolitan area is one community from a social and economic standpoint. Yet this unity is not recognized in matters of highway transportation.

The freeways may become our unifiers rather than barriers if we build and implement them wisely.

Palo Alto's Urban Renewal Plan

LEON K. RIMOV

Mr. Rimov is associated with the architectural and city planning firm of Schmidts, Hardman and Wong, Berkeley, California. He was formerly Planning Director for the City of Santa Cruz, California, and in this position he sparked that city's first urban renewal program. His current assignments involve working with both public and private officials on off-street parking, redevelopment, downtown rehabilitation and renewal, economic analysis of shopping centers and multifamily residential developments, large-scale site planning land-use studies, and schoolhouse planning. He is a member of the East Bay Chapter of the American Institute of Architects, the Institute of Planners, the American Society of Planning Officials and the International Federation of Housing and Town Planners.

PALO Alto, California—a city long famous for its Stanford University and research activities—has adopted a program to redevelop and rebuild a commercial and residential area of seventy-six acres without the use of state or federal assistance.

Unlike many cities throughout the country which have sought public subsidies in order to save their dying downtown area or community shopping facilities, the merchants and property owners, together with local public officials in Palo Alto, believe greater opportunities and satisfaction are possible by cleaning up one's own physical disorder with local energies, ideas, and financial resources. What has been accomplished and what is to be accomplished offer substantial evidence that there are tremendous potentials in following this approach.

California Avenue, a major shopping center in Palo Alto, is presently in the process of an economic and physical rebirth. This area is an older part of the city and was formerly known as the Town of Mayfield. Later it became known as South Palo Alto, and in the 1920's was annexed into what is now the City of Palo Alto.

The unique aspect of the development program in the California Avenue area is that this is basically an urban renewal project by private enterprise and will not require the use of federal subsidy

or supervision. Various types of business, industrial and professional firms have recognized the commercial opportunities now possible under this newly adopted program. Large, medium and small concerns have praised the plan as having tremendous investor appeal. Practically all firms concerned have identified a future role for their own particular concern in carrying out the over-all program.

As is the case with most urban renewal programs, an economic crisis had to exist before collective action on the part of landowners, merchants and public officials could be obtained. Many buildings along California Avenue had remained vacant for months—several had remained vacant for more than two years. Residential properties surrounding this commercial center had deteriorated to the point where they not only presented a fire hazard to the retail properties, but they also proved to be an economic burden to every taxpayer in the city. Retail activity was not what it should have been. Parking was inadequate. The main avenue of business was badly congested by intermixed pedestrian and vehicular travel. The avenue was unattractive. New buildings were built next to totally worn-out structures. The marquee on one shop blanketed out the marquee on another. Numerous problems beset the area, which required united action. More important, this need was clearly recognized by practically every merchant and property-owner on the avenue.

What has been accomplished in twelve months is a challenge for other cities, private investors and developers. Some of the objectives have been realized. Others will require one or two more years before any results can be seen. The entire program is gauged to a process of economic and social evolution rather than revolution. It is believed a period of five to eight years will be required for full implementation of the plan. A number of things have been accomplished during the last twelve months. For instance:

1. Under the leadership of a local realtor, a working non-profit organization has been brought into being to spearhead the planning effort and assist in financing some of the buildings for lease or sale to new or existing tenants along California Avenue. The correct creation of this non-profit organization was the beachhead upon which the merchants, property-owners, industrial and professional firms launched this urban renewal program.

2. New stores, large and small, are now in a position to locate in the retail area and be assured that incongruous retail activities or non-commercial land uses cannot develop adjacent to their place of business.

3. Land is presently being assembled without the use of eminent domain. In instances where buildings clearly present a physical and economic hazard to the entire community, they are being torn down or rebuilt in accordance with existing codes.

4. Simultaneously, the county is planning a two-and-a-half-million-dollar county office building in the project area, which will be located immediately adjacent to the commercial center of the California Avenue area. This will be a multi-purpose, multi-story building housing most activities normally found in courthouse offices.

5. A parking district has been created; a major portion of its bonds have been sold; and actual construction of free parking lots has been under way for more than four months.

6. Not only has the city responded to the need for strong code enforcement; the planning commission and the city council have amended the zoning ordinance so as to encourage, rather than restrict, efforts to build high-rise apartments and multi-story office and commercial structures.

7. Major access streets to the retail center are to be widened; small alleys are to be closed; some street utility lines will be re-routed—in short, approximately five acres of land and streets and rights-of-way will be returned to the tax rolls at the same time the circulation system is improved.

All this public improvement is to be done without increasing either the tax roll or the city's assessment structure. Palo Alto's city manager has stated, "Although the key to the success of this program is the action which private enterprise will take, the city's contribution is vital."

It should be mentioned that during the last nine years Palo Alto has undertaken many important multi-million-dollar civic projects, yet during this period of tremendous population and physical growth, the city's financial record has been enviable in that the city tax rate has been reduced from $1.30 to seventy-five cents.

8. Two large apartment buildings are scheduled for construction

early this summer. Neither one will require F.H.A.* assistance or a F.N.M.A.** standby commitment. A strong rental market exists. It has been accurately measured as to physical design, financial operation and projected performance.

9. Throughout the 76.6-acre area both commercial and residential buildings have been earmarked for demolition. Of the 120 single-family residences in the project area, only fifteen will not require extensive remodeling or rebuilding. Residents in the area recognize this. The merchants have also recognized that the entire Peninsula area is changing and that the present locational advantages of California Avenue deserve finer merchandising facilities and surroundings if they are to effectively serve the needs of Palo Alto and the population in nearby communities.

10. A one-and-a-half-million-dollar grade separation is now under construction which will link the residential foothill area with the San Francisco–San Jose Freeway. Its completion will assist California Avenue by directing heavy traffic adjacent to rather than through the retail area. This improvement will play a major role toward removing the conflict between pedestrian and vehicular traffic.

11. Immediately adjacent on the west of the project area is Stanford's Industrial Park. For a number of months an extensive development program has been under way for attracting light industrial and manufacturing firms. Some of the firms presently located, or in the process of locating, in this Industrial Park include Eastman Kodak Company, Varian Associates, Hewlett-Packard, Lockheed Aircraft, General Electric, Forsman and Clark, Ampex, and Spinco, a division of Beckman Instruments.

12. For years California Avenue has been the transportation hub for commuters living in such nearby communities as Mountain View, Los Altos, Menlo Park and Los Altos Hills. These commuters represented a market which deserved proper retail facilities. The presence of this transportation facility posed numerous unusual problems. For example, residents drive their personal cars to this railroad station and are provided free all-day parking. Although the Southern Pacific Company provides extensive commuter facilities, it derives no revenue from this parking but is required to

* Federal Housing Administration.
** Federal National Mortgage Association.

pay certain taxes for the land involved. Overflow parking flooded nearby streets and "free parking" lots, thus depriving local merchants of badly needed parking spaces. Between 7 and 8 o'clock in the morning and from 4 to 6 o'clock in the evening, as many as 2,000 cars per hour jammed streets only forty to sixty feet wide. The ultimate solution had to be acceptable to the city, the motorist, the commuter, the railroad company, the city taxpayer and all merchants and property-owners involved.

One of the features of the proposed transportation terminal will be to provide joint use by rail, bus and air concerns. A detailed shopping plan catering exclusively to this commercial traffic has been planned and incorporated as part of the over-all development.

What is taking place is not the result of chance, guesswork or sheer opportunism. Judgment and planning strategy, together with keen technical analyses, were required. A step-by-step plan was prepared, including the study of such factors as:

1. City and county land use; taxation trends.
2. City and county capital improvement programming.
3. An analysis of commercial land uses, occupancies, leasing procedures and merchandising operation.
4. Real estate practice and appraisal operations in Palo Alto and the California Avenue area.
5. An analysis of construction cost, financing and programming procedures.
6. Internal analysis of retail management and merchandising.
7. Parking, public transportation and circulation.
8. Co-ordinating public and private construction programming so as to complement and develop the California Avenue area with the maximum resources locally available.
9. Public relations, education, advertising and promotion.

The entire group that began this operation recognized that the interest of those involved cannot be held for more than five to eight years. For this reason, an eight-year deadline was set.

Business and industrial leaders also recognized the importance of employing an impartial and outside organization to guide them and conduct the technical studies involved. An accurate appraisal of the area's assets and liabilities had to be prepared, evaluated and presented in an organized and logical form, divorced from personalities and local business responsibilities. In addition to employing

business analysts, retail merchandising specialists, appraisers, traffic engineers, professional planners, investment analysts, bond counselors, accountants, engineers, and statistical analysts, the ideas and energies of those persons and groups who lived and worked in the California Avenue area had to be incorporated in the program if the plan were to prove workable.

Furthermore, it was felt that any firm selected had to employ specialists who could create and evaluate these ideas and come up with something new, yet resourceful; challenging, yet practical.

Two firms were commissioned to assist in developing the workable tools and planning techniques necessary for implementation of the renewal program—an economic and merchandising consulting firm, and an architectural and city planning firm.

Immediately following selection, these two firms took as their first step of action the formation of a non-profit foundation, which later became known as the California Avenue Development Association, Inc. The purpose of forming this foundation was twofold. First, this foundation could function as a means of correlating local ideas, energies and financial resources. And second, as an organization representing many business, industrial and individual interests, ideas and energies would be respected at a later date when the plan and program were ready for presentation and adoption by all public agencies concerned. The composition of the executive committee consisted primarily of prominent civic business and industrial leaders: a realtor, a professional engineer, a pharmacist, a jeweler, an attorney, an insurance broker, a banker and a landscape architect. Each member of the executive committee was later made responsible for a specific assignment. As an illustration, the committee responsible for housing of the elderly, working on problems of education, housing relocation, absentee property owners and problems related to residential financing, was handled by the realtor.

Another instance in which the executive committee worked with a subcommittee was on off-street parking problems. Here, the subcommittee was responsible for reviewing the planning consultant's recommendations for locating and financing off-street parking facilities, the closing of certain streets, and the widening of others. In conjunction with this study a great deal of technical information was passed on to each property owner, so that each

owner and merchant understood what was taking place in the area at all times. Working with the leasing committee, these two groups analyzed recommendations for changing land uses and changing leasing requirements in order to reflect the changing needs of property owners and merchants on the avenue.

The merchants' advertising and promotion committee held many a "brain-storming" session and came up with ideas that can result in better merchandising, better area-wide advertising, and better promotions geared to the market that patronizes their area and retail outlets.

Problems relating to architectural lighting and display, both in the daytime and in the evening, had to be considered. Plans for landscaping of pedestrian malls had to be evaluated.

Parkway development and marquee displays were handled both by this committee and by the consultants' technical planners. The entire plan and program not only had to be technically correct, but it also had to be humanly appealing. It had to be prepared to reflect the competition that existed in retail merchandising, and be able to recognize the complex characteristics of the consumers' purchasing power.

Not only were shops in the area itself evaluated with respect to one another, but shopping centers within the city and shopping centers located in other cities were considered as part of the over-all program.

This evaluation called for conducting a scientifically-prepared personal interview to obtain, record and analyze attitudes, desires, habits and needs. This information had to be obtained and held in strict confidence. Each merchant was given information relating to his own operation, but received no data concerning his closest competitor.

Following the survey, and being apprised of the commercial possibilities on the avenue, each merchant was shown reasons why an extremely healthy future could exist if certain merchandising and traffic obstacles were eliminated, run-down physical structures removed, and existing building and zoning ordinances revised.

Other basic objectives agreed upon at an early date were:

1. The project area should consist of inter-related and complementary high- and low-rise residential, retail, office, and professional structures. Architecture was to be considered an inter-related part of zoning and land use. Zoning by itself would prove inadequate.

2. A visually attractive environment had to be developed which would stabilize retail operations and serve as a pattern for attracting future progressive outlets of the stature and types indicated by the field survey.

3. The adopted program must include some provisions to prevent further piecemeal development or the development of unrelated physical and economic activities within the newly established land uses of the area.

4. Only those land uses and retail activities which were compatible would be permitted to locate in the area. Sociological as well as economic factors are constantly at play in today's retailing operations. Knowing and pinpointing a market is essential for a shopping center's success.

5. Wherever possible, both public and private buildings should relate to the changing character of the Palo Alto area.

6. The redevelopment plan should be privately financed and administered, calling upon public agencies for public actions only at such times as assistance was necessary to implement planned parking, utility, traffic or population-density changes.

In determining some of the physical, industrial, commercial and residential assets and liabilities of the area, an inventory was taken, a balance sheet was drawn and an action program formulated to expand the assets and reduce the liabilities. Specific trade areas were precisely outlined and measured and, later, zones established whereby information pertaining to consumers' spending habits, purchasing power, occupation, housing requirements, age of dwelling structures, change of land use, commercial and recreation needs, comparative buying habits and factors relating to retail pricing, selection and quantity could be obtained. Retail efficiency was evaluated and presented on a basis of a weighted average index so as not to disclose the confidential information which each merchant voluntarily offered. Nor were the personal shopping characteristics of any particular family or their ideas ever revealed.

Detailed economic research and physical planning were interrelated throughout the entire plan and program. Thus the final plan was the result of knowing the expression of individual needs and aspirations, the mercantile tempo, the obligations of government, and the unused and undeveloped assets of the area and the community.

In studying the commercial area, two steps were evolved to

realize the development of a specific plan. The first was to take the existing store activities, locate them on a map, showing the relationship to one another. On the same map was indicated what each store carried in terms of merchandise, and what was available for competitive pricing and selection. The staff also described the type of building housing the various types of merchandising. Time and distance factors were considered. In instances where a large supermarket carried more than one item, a more intensive study and breakdown of sales items were required.

The second step was to regroup these activities and find out which merchants had made long-term commitments for remaining in the area and which had not—which ones developed a successful merchandising program, and again, which merchants did not. Following this, a grouping of activities was initiated. When all of the information was obtained, it was possible to establish clearly an area for food products, an area for soft goods, an area for hard goods, an area for financial, and an area for residential and thoroughfare commercial.

Following identification of these, a specific plan was formulated and a realistic and positive zoning ordinance drafted, relating to the economics of the area. Such an ordinance would prove valueless to another community—perhaps even injurious—if duplicated without recognizing that the economics of one city differ considerably from the economics of another. It was recognized that if the commercial area were to be properly developed, subsequent redevelopment of the surrounding residential area was essential. Up to this time the existing zoning ordinance restricted buildings to a three-story limitation. Under the newly adopted plan and program the intentions and the objectives of the zoning ordinance are preserved. The land, zoned in accordance with the new zoning ordinance, offers an incentive to assemble properties by individual property-owners, or by a larger firm financially responsible and able to assemble a better residential development.

Properties can be obsolete, too, in that they are improperly plotted. A 25 by 100 foot property cannot afford a satisfactory development to be built on it today. Even a 50 by 100 foot lot, in some instances, is unsuitable. One feature of this zoning ordinance is the "sliding scale" provision. The accompanying table points out that as more parcels are assembled, more units can be built on

the assembled property. Each developer and property-owner or investor knows immediately what can and cannot be developed on a given piece of property. Unlike many ordinances, an attempt has been made to simplify the process of communicating public requirements to prospective investors, lenders, realtors or developers. The accompanying zoning table indicates how this works.

For a parcel 50 by 100 feet, only two units can be erected. The lot area required would be 2,500 square feet. However, if a developer were to assemble a piece of property 100 by 200 feet, or 20,000

Table I

SECTION 9C . 11 LOT AREA AND LOT AREA PER DWELLING UNIT

Number of Units	*Lot Area Per Unit (Square Feet)*	*Decrease Each Interval*	*Total Lot Area (Square Feet)*
2	2,500	170	5,000
3	2,330	170	7,005
4	2,165	165	8,680
5	2,000	165	10,000
6	1,900		11,400
7	1,800		12,600
8	1,700	100	13,600
9	1,600		14,400
10	1,500		15,000
11	1,440		15,840
12	1,380	60	16,560
13	1,320		17,160
14	1,260		17,640
15	1,200		18,000
16	1,170		18,720
17	1,140	30	19,380
18	1,110		19,980
19	1,080		20,520
20	1,050		21,000
21	1,030		21,630
22	1,010	20	22,220
23	990		22,770
24	970		23,280
25	950		23,750
26	940		24,440
27	930	10	25,110
28	920		25,760
29	910		26,390
30	900		27,000

Table I (*cont'd.*)

Number of Units	*Lot Area Per Unit (Square Feet)*	*Decrease Each Interval*	*Total Lot Area (Square Feet)*
31	895	5	27,745
32	890		28,480
33	885		29,205
34	880		29,920
35	875		30,625
36	870		31,320
37	865		32,005
38	860		32,680
39	855		33,345
40	850		34,000
41	845		34,645
42	840		35,280
43	835		35,905
44	830		36,520
45	825		37,125
46	820		37,720
47	815		38,305
48	810		38,880
49	805		39,445
50	800		40,000
51	795		40,545
52	790		41,080
53	785		41,605
54	780		42,120
55	775		42,625
56	770		43,120
57	765		43,605
58	760		44,080
59	755		44,545
60 and over	750		45,000

Schmidts, Hardman and Wong

square feet, eighteen units could be put up, with only a lot area of 1,110 square feet. This zoning ordinance was purposely developed in conjunction with the mortgage retail pattern that has existed in Palo Alto for the last twelve years.

In the course of the study it was discovered that the rental pattern for a one-bedroom apartment in Palo Alto was $10 to $15 more than for apartments in surrounding cities, and upwards of

$50 to $75 for two-bedroom units. On the basis of accurately relating mortgage and rental features to land-use potentials in Palo Alto, a better zoning ordinance has been designed to reflect the uniqueness of this community.

Far too many of today's communities have adopted a zoning ordinance independent of current financial development policies and features. City officials, merchants, property owners and industrialists affected in the problems of urban growth can attest to the fact that an improperly conceived zoning ordinance can do great injustice to the community's proper development and role in a growing community.

The approach taken by the California Avenue Area Development Association, Inc. toward meeting the problems of urban development and growth would not have been possible had the persons sparking this program lacked the imagination and energy to build something better. As the city manager of Modesto, California, once said, "While many, many details and processes are required in the progress of a development project, there is one priceless ingredient—the desire and the will to see it through."

Some Traffic Factors in the Central Area Development

CARL W. ALMBLAD

Mr. Almblad has been the principal city planner of the Detroit City Plan Commission since 1953. He is responsible for long-range studies, the master plan, and for redevelopment project plans. From 1950 to 1953, he was with the Chicago Plan Commission, working on the metropolitan study, redevelopment plans, and plans for out-lying sectors of the city. Mr. Almblad is an Associate Member of the American Institute of Planners, a Member of the Michigan Society of Planners, and a Registered Architect in Illinois. In 1954, he spent three months in Europe studying city planning in ten countries.

A RECENT report indicated that nearly a billion dollars in public and private construction is currently programmed in Detroit, all of which will do much to enhance the position of the Detroit Central Business District as the heart of a great metropolitan area.

Within or adjacent to the central business district itself, over 400 million dollars of investment are completed or programmed. These commitments and accomplishments, if properly co-ordinated and carried out, will maintain the competitive advantages available in the central business district.

In less than ten years, improvements have already had an impact on the central business district. Expressways have reduced traffic volumes on thoroughfares as much as fifty percent and measurably reduced travel time between the central business district and outlying parts of the city.

In conjunction with this, seven parking structures have recently been completed in the central business district, indicating the trend toward better utilization of land for parking facilities. Clearance and construction in the civic center and in the redevelopment area adjacent to the central business district has and will continue to improve the position of the central business district.

Not only are they providing an opportunity for improving the traffic pattern but they are removing the slum areas similar to

those infecting downtowns everywhere, and are providing new housing to improve the central business district market and improved facilities servicing the central business district. Evidence of this can be seen in the building program being undertaken adjacent to the civic center—including two major bank buildings, a bus terminal, the gas company's new headquarters, improvements to existing buildings, and the possibility of a hotel and a new federal building.

To plan with an objective too limited may be no more sound than to make no plans at all since a small amount of misplaced development may for all time defeat the accomplishment of a broad and effective master plan. This is particularly true in the

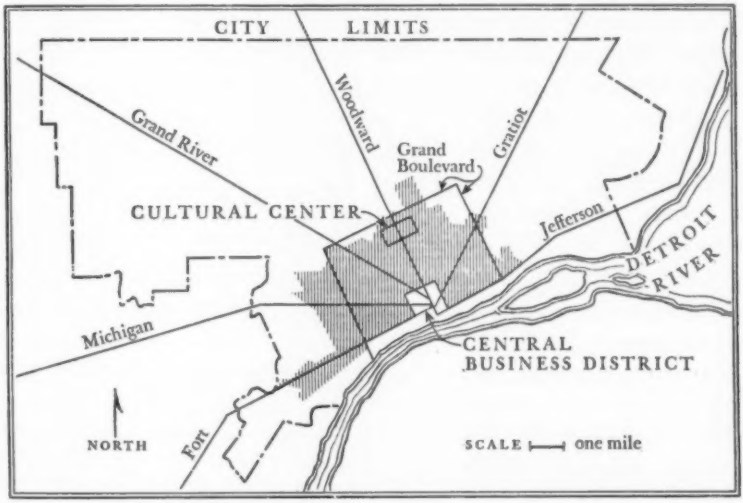


Figure 1. Detroit, showing blighted residential area.

case of trafficways. New building construction of a comparatively limited nature may easily freeze the street pattern in an entire sector of the city. With this in mind, Detroit's City Plan Commission is placing great emphasis on its overall, long range plans when undertaking redevelopment and other civic improvement.

Detroit's blighted areas are located largely within its "boulevard" area (see Figure 1) and projects undertaken thus far relate closely to the central business district and the "corridor" connecting

the central business district to the cultural center. It is primarily this area which will be considered here.

As can be seen from Figure 2, the Woodward corridor and the central business district have developed with an over-laid net of thoroughfares carrying both vehicles bound for the area and through-traffic. As is the case with most nets, it is liable to get tangled from time to time.

As traffic demands increased, many of the thoroughfares were paired off into one-way streets in order to best utilize existing pavements. On the face of it, this system of one-way streets plus the expressways seems to be adequate. But on the face of it, only. Consider Highland Park, an independent community located north of the corridor. Virtually every north-south street in the city is a thoroughfare. It is not difficult to see what effect this has on residential neighborhoods and other land-use patterns. Proposing a redevelopment plan with such a grid of streets freezing the land-use pattern would be limiting its potential greatly.

Perhaps the deficiency most noticeable to a planner is the inflexible arrangement of the land. There is no freedom to arrange streets to accommodate developments which may be proposed. There is greater interference between paths of pedestrian movement and the streets. Groups of uses which maintain a great amount of pedestrian communication may be separated by streets. One-way streets usually provide a difficult route of access for certain movements. Anyone who has had to circle half a dozen blocks on one-way, downtown streets in order to get to a point half a block away will understand this. An excessive number of intersections, each tending to hamper traffic, is required.

It might be argued that the one-way street facilitates left-turn movements. While this is true, it is also true that adequate provisions can be made on the two-way street for left turns. Three methods are utilized in Detroit. The simplest is the provision of a center lane reserved for left turns only. The provision of a median strip which is indented at the intersection for left turns is also used. The third method which is perhaps not as satisfactory occurs where the intersecting street has a median strip. Here, vehicles make a right turn first, then turn left across the median strip, and left again into the desired direction.

If a community is to take full advantage of the opportunities offered through redevelopment, it is important that traffic planning

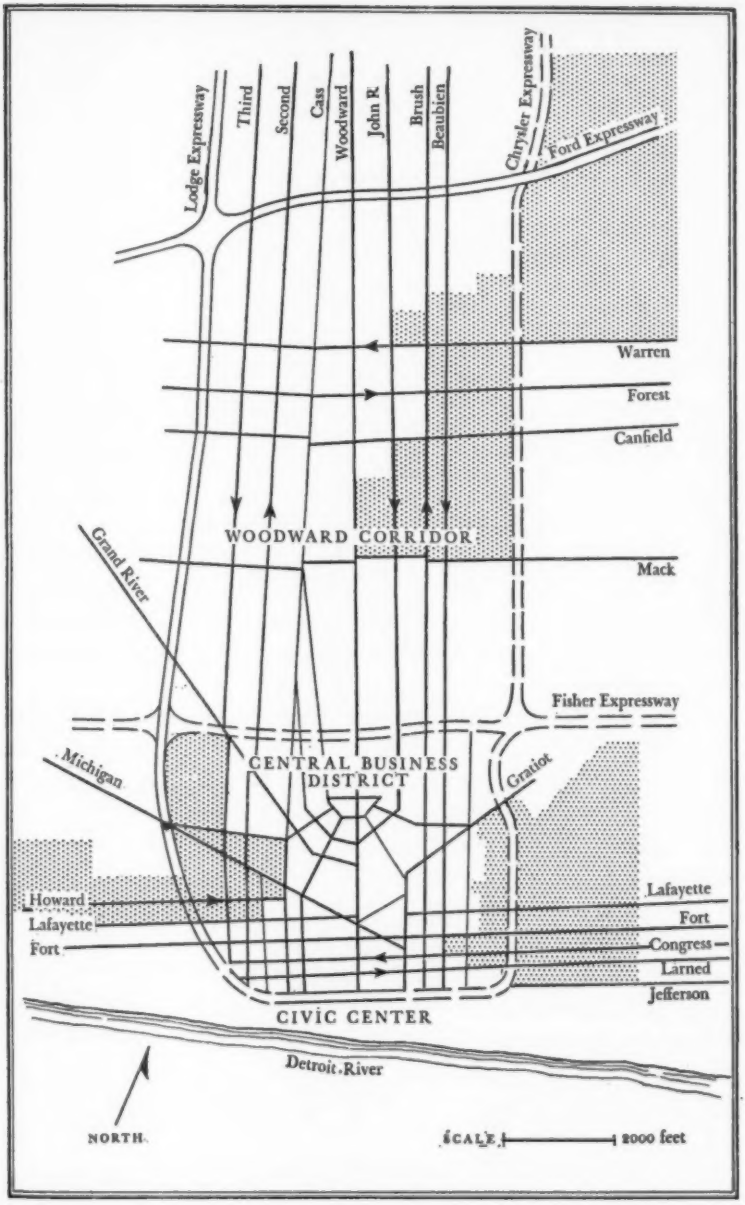


Figure 2. Woodward Corridor and Central Business District, showing existing thoroughfares and redevelopment and other projects.

be done on a broad scale first, relating all the redevelopment areas together. It is possible, through staging, to create a new and improved thoroughfare system for a complete sector of a community. If clearance projects are undertaken on an individual basis, little can be accomplished toward obtaining a flexible and ideal pattern of development even for the project area itself.

Trafficways: Central Business District

The plan for the central business district and related redevelopment projects is based on the concepts discussed above. As can be seen from Figure 3, the central business district is formed by the expressway ring. Traffic is brought off the expressways and the radial penetrating the ring, to adjacent parking facilities or onto the boulevard ring for further distribution to parking facilities.

Within the boulevard ring and convenient to its parking facilities are the central retail business area and related financial and entertainment facilities. Between the boulevard ring and the expressway ring are other related uses: to the south is the civic center, on the west is the Convention Mall, on the east the governmental and institutional center, and on the north are locations for downtown dwellings.

Work on the expressway system relating to the central business district is well underway. The John C. Lodge Expressway, forming the west link, has been in use a number of years. Extending in a northwest direction it will, in a few years, connect with an expressway leading to Lansing, the state capital. Late this year, the Lodge link (under the Civic Center Exhibits Building) to Jefferson Avenue on the south of the central business district will be completed. Part of the improvement of Jefferson Avenue has also been completed. Construction has begun on the east side expressway, the Walter P. Chrysler. Since a portion of the route was cleared several years ago, construction will move fast in this area. This route will link up with Jefferson Avenue also, at the southeast corner of the central business district. The Fisher Expressway, which will cross the central business district at its north boundary, is slated by the city to be the next route to enter the construction phase.

Although the "skid row"-Convention Mall Area is presently crisscrossed with thoroughfares, the plan submitted to the Urban

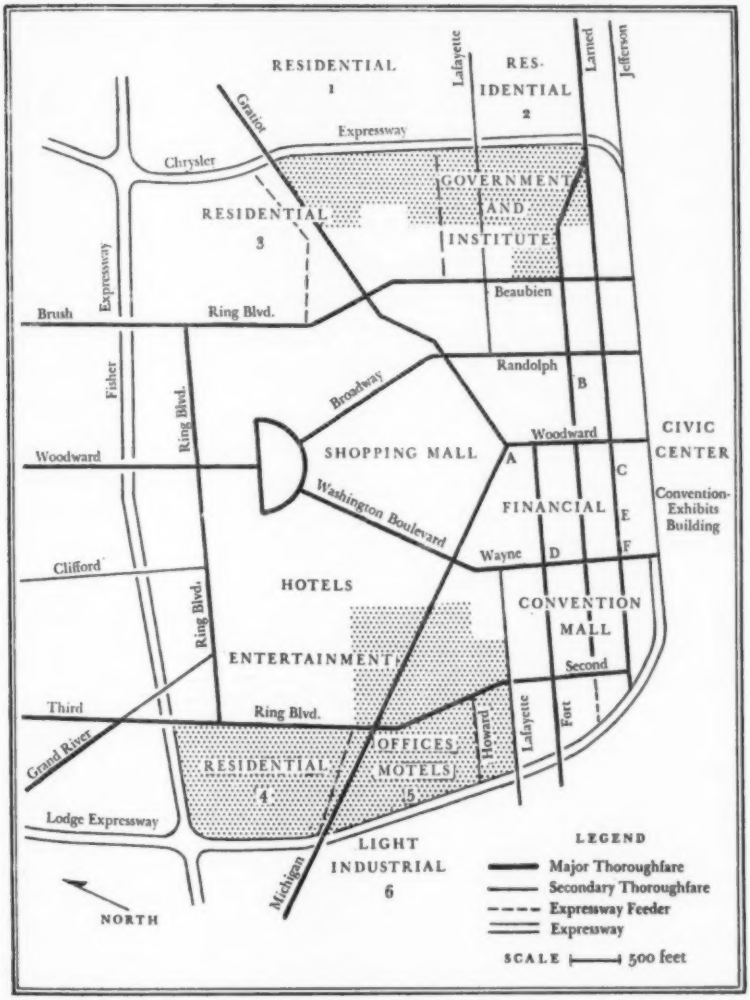


Figure 3. Central Business District thoroughfare plan.

Renewal Agency for two redevelopment projects in this area (C.B.D. numbers 1 and 2—see Figure 3) replaces most of the north-south streets with the west link in the boulevard loop. This acts as the main distributor to the area. It is anticipated that this route will consist of two thirty-six-foot roadways divided by a twenty-four-foot landscaped median strip. Margins of fifteen feet are proposed. It is believed that this ample boulevard will help produce excellent building sites as it passes through the area.

The first area affected by this route is the C.B.D. number 2 redevelopment area, proposed for a combination of townhouses and high-rise apartments. By eliminating many of the existing streets an eighteen-acre area uninterrupted by through-traffic is provided. Served by an exterior loop street, the area will provide maximum flexibility for the development of housing, local shops, and open space. Parking, which is to be provided under a continuous landscaped deck, is described later.

Further south, in the C.B.D., the ring boulevard enters an office area and motel-shop district. These two areas are interconnected with a landscaped deck providing uninterrupted pedestrian passage between parcels of land without constricting vehicular traffic below it.

Connecting the north approach to the Convention-Exhibits Building in the Civic Center is a similar pedestrian deck. This "Convention Mall" will provide sites for hotels, restaurants, and shops catering to convention trade.

Plans for both C.B.D. number 1 and C.B.D. number 2 have been completed and submitted to the Federal Urban Renewal Agency for approval. It is expected that a loan and grant contract can be negotiated before July 1st and demolition started before the end of the year.

Although the Detroit master plan does not include specific locations for traffic routes in the central business district, a master plan of the central business district has since been prepared. It is on the basis of this plan that redevelopment plans and restrictions are prepared. Such redevelopment areas offer real opportunities for accomplishing such a revision in traffic routes and land uses. Although the long range traffic pattern for the central business district was initially prepared by the city plan commission, it has been revised through the assistance of the Department of Streets

and Traffic and it is this department which can implement the plan as the occasion arises.

One important item is the matter of proper staging when only portions of a route are to be completed at first. Transition from existing pairs of one-way streets to new two-way boulevards, for example, must be provided at a minimum cost, using existing streets if possible.

A serious problem in this area of improvement is the refusal of the Federal Urban Renewal Agency to accede the benefits of such overall planning toward the sale and development of land in redevelopment projects. It has been their position, for example, that the value of land in a downtown residential area or office area is not increased by replacing the present gridiron pattern of streets with a co-ordinated system of distribution providing larger, more flexible parcels of land. On this basis, urban renewal funds for trafficway improvement within a project are refused. It would appear that more experience in these types of areas will be necessary before the agency alters its stand.

Civic Center

The Civic Center, started in 1945 and nearing completion, contains the Ford Auditorium, Veterans Memorial Building, City-County Office Building, and the Cobo Hall Convention Center which is being booked for conventions in 1961.

The Civic Center is located at Detroit's riverfront adjacent to the central business district. Directly to the north is the hotel district, centered mainly near Washington Boulevard. It is apparent that Detroit should take every possible advantage of this convention center investment by making this quarter of the central business district more pleasant and attractive.

When it was determined that a convention hall and exhibits building should be built at the waterfront in the civic center, there was a major planning problem to get satisfactory pedestrian access to buildings. The Lodge Expressway connection with Jefferson Avenue would make the approach to the convention area quite difficult.

The final determination to locate the exhibits building over the

expressway has two advantages regarding circulation. First, pedestrians coming to the area may approach the buildings at surface level completely separated from the expressway traffic. Second, the entrance to the exhibits building is brought one block farther north, closer to the hotel and business area.

Vehicular traffic destined for the civic center may approach on the Lodge Expressway (completed) or the Chrysler Expressway via Jefferson Avenue. In addition, both Wayne Street (continuation of Washington Boulevard) approaching the Civic Center from the hotel and shop area, and Randolph Street have been recently widened.

In addition, Woodward Avenue, approaching the civic center at its heart, is in the process of being improved. To facilitate this, demolition of all buildings on its frontage for a three block stretch connecting the business area with the civic center is planned. This will provide an additional seventy feet for widening which will accommodate two forty-four-foot pavements, a forty-foot median and a forty-foot-wide landscaped pedestrian walk on the west side in addition to the existing walk on the east side.

The northern block has been demolished and a new major bank building, ready for occupancy in June, will front on the widened walkway. Demolition in the remaining two blocks will begin this month. The south block will contain a new main office building which will begin construction shortly. Strong interest in the center block has been shown for use as offices or for other uses.

Directly north along Woodward Avenue is the principal shopping district. Plans call for a pleasant pedestrian mall to be provided. This would contain not only landscaping and sheltered walks but kiosks, restaurants, sculpture, etc., designed to attract shoppers to the area.

The Woodward Corridor

The Woodward Corridor (see Figure 4) forming the entry to the central business district from the north, is now undergoing change. Constructed are the John C. Lodge and Edsel Ford Expressways, forming the Corridor's west and north boundary. The Walter P. Chrysler Expressway, under construction and the Fisher Expressway, soon to be begun, form the east and south boundary of the Corridor. The rapid expansion of Wayne State University in the

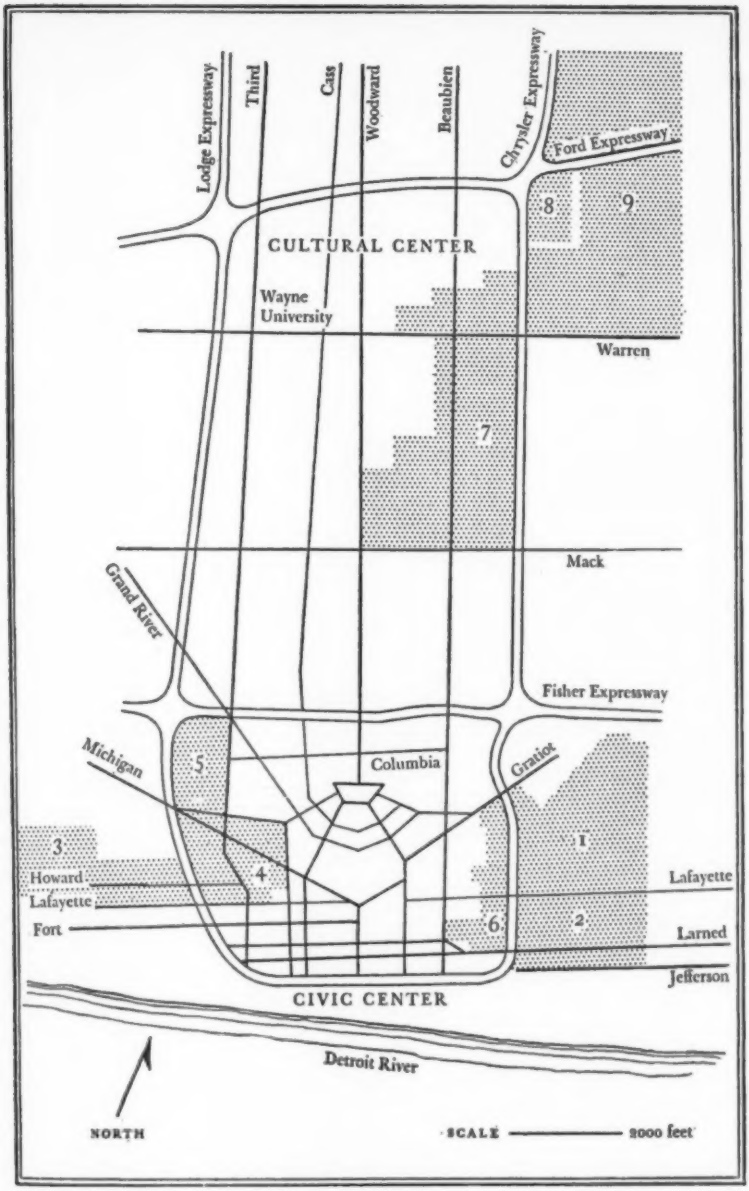


Figure 4. Redevelopment projects in the Central Area.

1. Gratiot—Housing. 2. Lafayette—Housing. 3. West Side—Industrial. 4. Central Business District—Commercial. 5. Central Business District—Residential. 6. Central Business District—Institutional. 7. Medical Center. 8. Milwaukee Junction—Industrial. 9. Milwaukee Junction Study Area—Industrial.

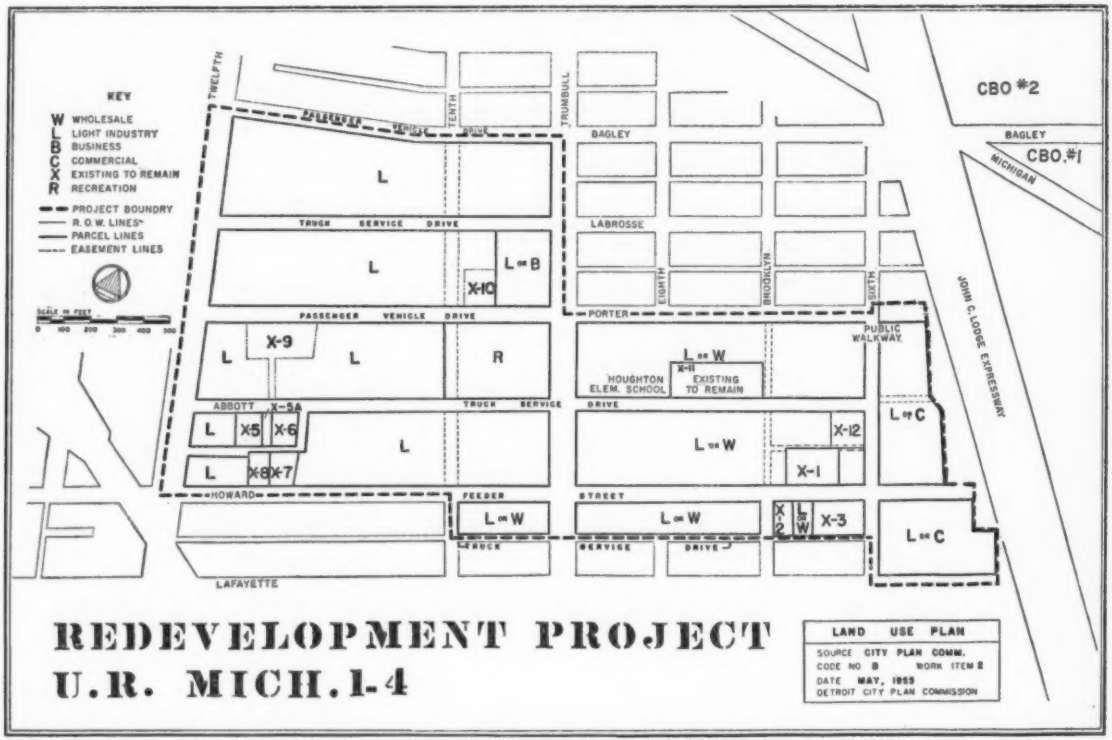


Figure 5. West Side industrial project plan.

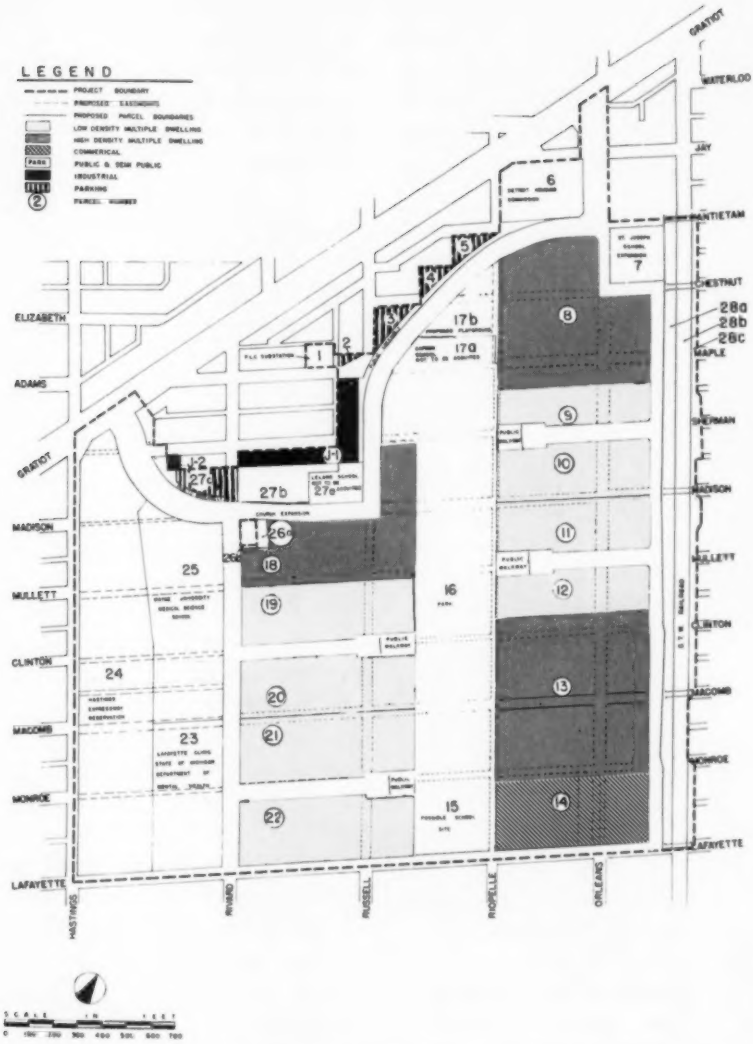


Figure 6A. Residential redevelopment showing Gratiot and Lafayette project plans.

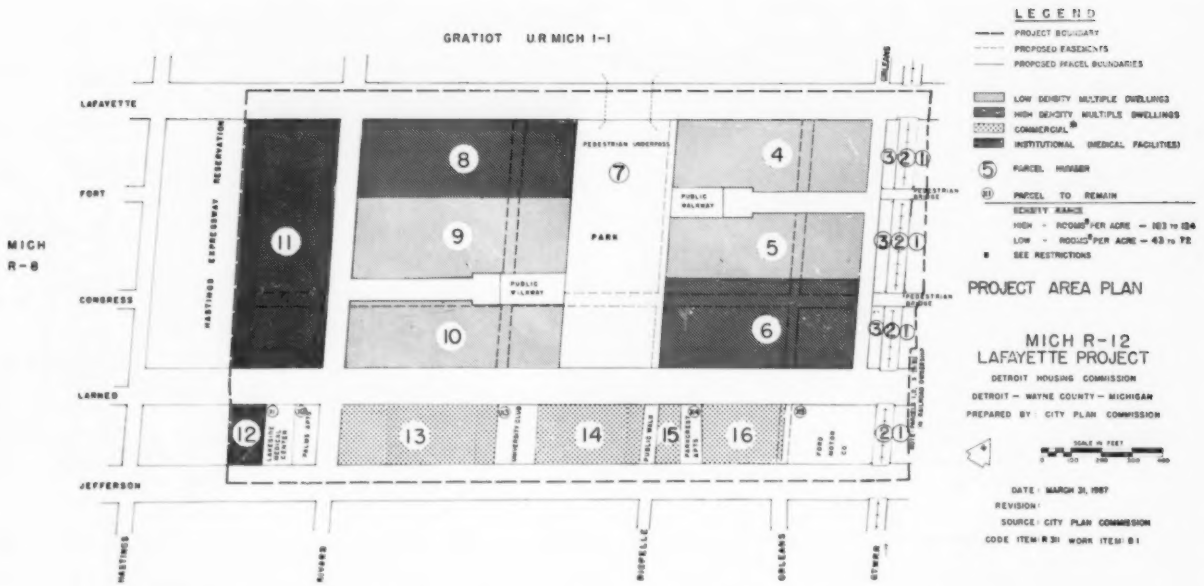


Figure 6B. Residential redevelopment showing Gratiot and Lafayette project plans.

Cultural Center will result in the reconstruction of the northwest sector of the Corridor.

Substantial progress in vacating excess local streets has been accomplished in the area of Wayne State University. Approval has been given to divert one street of a pair of one-way streets in order to carry the traffic around the central part of the campus. The diverted street will be relocated adjacent to the second street of the pair, thus forming the first stage of the divided roadway that will extend down to the central business district and into C.B.D. number 1 and number 2 projects.

To the east and south of the Cultural Center lies the Medical Center Area. This area, containing four major hospitals, has been slated for clearance. Besides the hospitals which will remain, the area is characterized by residential structures beyond repair and occasional factories and commercial structures.

It is planned to develop 236 acres of the total 307 acres comprising the Medical Center Area with federal urban renewal assistance. An application for a general neighborhood renewal project (GNRP) has already been given federal approval and planning is proceeding.

The redesign of this segment of the city poses many problems. One of them is the street pattern, which must be integrated with plans for the whole corridor. The basic framework is that of the Detroit Master Plan, which proposes the Chrysler Expressway on the east, Woodward Avenue on the west, Mack Avenue on the south, and Warren Avenue near the north, all major thoroughfares.

The north-south through-traffic, at present handled by three of the four north-south streets, will continue to adversely affect the development. Revision of this pattern is essential if the new development is to be worthwhile.

It is therefore proposed that this through-traffic be taken by a two-way street through the center of the area, depressed below grade with ramps providing access at the north (Warren) and south (Mack). Staging will be important as this will necessitate some revision in the street pattern beyond the limits of the Medical Center.

Within this framework, the local street system can be developed so as to embrace three of the four existing hospitals within a large parcel of land set aside for buildings devoted to medical care, teaching and research. A two-way, four-lane peripheral drive, with ample dividing strip to facilitate left turns will enclose these medical

uses providing access to them and to the ring of residential and other related uses surrounding it. In this way, the unnatural mixture of vehicular and pedestrian traffic will be minimized and it will be possible to develop an atmosphere of tranquility and beauty where the automobile is the servant and not the master of man.

Industrial Plan

In the West Side Industrial Project, a redevelopment area of seventy-five acres, demolition has begun on the first stage of the area and it is expected that land will be offered for sale for light manufacturing and warehousing in May. The original street pattern in the area consists largely of fifty-foot rights-of-way and forming blocks measuring 280 feet by 350 feet. Blocks are bisected by alleys, thus providing parcels 130 feet deep.

In its *Industrial Study*,[1] a mailed survey covering industry in Detroit, respondent industries voiced traffic congestion as a major concern. In order to provide conditions conducive to smooth traffic flow in the project, the redevelopment plan aimed at reducing the number of intersections, providing maximum use of pavement by moving vehicles and separating different kinds of traffic.

The Redevelopment Plan (see Figure 5) calls for vacation of alleys in the new plat, providing 285-foot parcels extending from street to street. In addition, north-south streets are to be vacated except in the case of Sixth Street (service drive for the Lodge Expressway) and Trumbull and Twelfth Streets (thoroughfares). Access to the development will be from one of these three remaining north-south streets onto the east-west streets in the project, which will in turn provide access to the parcels. The use of these east-west access streets will be limited so that alternate streets will be truck service drives and passenger vehicle streets. Thus, each parcel will have a service drive at one end and a passenger vehicle street at the other end.

Truck service drives will be developed with a full fifty-foot right-of-way, all of which will be available to traffic except for a raised, three-foot-wide section on both edges which will contain

1. Industrial Study, Detroit City Plan Commission, 1956. Through a mailed questionnaire, having a response of 65 percent, the study delved into the problems of industry in Detroit. It touched on such items as location and size of plant, expansion needs, obsolescence, parking, loading, and traffic problems.

light standards, etc. The passenger vehicle streets will provide a thirty-six-foot pavement in a sixty-foot right-of-way. Parking will be prohibited on all streets. While a fifteen-foot building setback is indicated along passenger streets, no open space is required along the service drives.

Residential Concepts

The plans for the Gratiot and Lafayette Projects combined (see Figures 6A and 6B) are aimed at providing a complete Master Plan neighborhood with as little conflict of pedestrian and vehicular traffic as possible. Basic to it is a flow of pedestrian movement through the central park, connecting dwellings, school and shops. It is anticipated that the pleasantness of the area combined with the absence of vehicle crossings will encourage residents to walk rather than use their automobiles when making local trips, thus reducing traffic demands on local streets.

Vehicular traffic is handled on a ring street circuiting the neighborhood and connecting to cul-de-sacs which offer access to off-street parking facilities. Cul-de-sacs are provided with a landscaped median strip and two twenty-two-foot roadways, permitting curb parking.

Since this redevelopment area is adjacent to the central business district, large traffic volumes formerly traversed the area. As provided by the plan most of the bridges over the depressed railroad tracks to the east of the area have been demolished and indiscriminate through-traffic curtailed.

Because of anticipated traffic volumes, however, one thoroughfare will traverse the neighborhood. This street (Layafette) will be boulevarded with a median strip in order to minimize its effect on adjacent dwellings. In addition, the plan calls for a 150-foot wide swale under Lafayette, connecting the two portions of the neighborhood. This swale is to be developed in such a manner that the park landscaping can be carried into it so that the park is uninterrupted and persons will be invited into it.

Parking: Residential Redevelopment

As might be expected, a city relying on private passenger vehicles for transportation must impose firm parking requirements

in urban renewal areas. In the Gratiot Redevelopment Project (now called Lafayette Park-University City by the developer), Detroit was determined to provide a complete neighborhood of urban living at its best. Therefore, besides providing for open space and separation of vehicular and pedestrian traffic, the plan included off-street parking requirements.

When the plan commission began preparing the Declaration of Restrictions—as far back as 1950—the requirement of at least one off-street parking space per dwelling unit was included. The restrictions for the redevelopment project further state that the location of the parking is subject to the approval of the plan commission. This is to assist in insuring that the parking will be provided not only in convenient locations but so as to allow the best development of the remainder of the open space for landscaping, play areas, and walks.

West Side Industrial

The West Side Industrial Redevelopment Project brought the parking needs of industry into focus. In its *Industrial Study*, the Plan Commission found that fifty percent of industrial employees in Detroit drive to work. Based on this information, the Declaration of Restrictions for the West Side Industrial Project requires at least one parking space for every two employees on the largest shift, or one space for each 550 square feet of gross floor area, whichever is greater. The latter is also based on findings of the *Industrial Study* concerning square feet per employee in Detroit. In addition, off-street parking is required for trucks, though not specified as to amount.

Central Business District

These heavy parking requirements imply that in high density areas we must come up with some effective proposals for parking of these vehicles as well as moving them. A study of the existing land-use map for the Detroit central business district reveals that forty percent of the net land area is devoted to automobile parking. This is composed largely of open, surface parking, twelve parking structures being involved. Parking rates range from short term lots at fifty cents for the first hour plus thirty cents for each additional half hour, to forty cents all day on the peripheral lots. Because

of the demand for parking, it has been profitable in many cases to demolish commercial structures and use the land for parking lots.

Practices in providing parking for employees vary. One company, for example, employing some 2,700 persons in its downtown offices, provides only an insignificant number of parking spaces in a garage for executive staff. At the other extreme is a company employing over 2,300 persons in its downtown offices and providing lots for the parking of 1,125 vehicles. At first glance, the practice of the latter company seems laudable. Yet one must consider what the effect on a downtown would be if every business provided surface parking for almost fifty percent of its employees. It is apparent that the central business district would consist of a vast sea of cars interrupted here and there by a solitary office building.

It is apparent that the answer to parking needs does not lie in providing a surface parking space for each vehicle destined for the central business district. This fact was recognized in planning for the redevelopment of the "skid row" area in Detroit's central business district. In the northern part of the area designated C.B.D. number 2 Project and proposed for residential use, surface parking at the required rate of at least one space per dwelling unit would have required ten of the eighteen acres of land in the project. After deducting streets and building coverage from the remaining eight acres, little would be left for open space. To meet this situation a rather unique plan has been prepared.

The basic intent was to develop sufficient parking space while leaving as much space as possible for other purposes. Multi-level garages were considered. Yet even these will require some land and four- or five-story garages would not necessarily add to the convenience of parking or to the landscape. The plan makes use of an extensive deck structure containing two levels of parking—one, four feet below grade and the other four feet above grade. The top level of parking is to be covered with a landscaped deck on which the housing units—both townhouses and apartments—are to be located. This arrangement would have advantages. Besides providing a maximum amount of open space, it permits direct, covered access from parking to dwellings and offers protected or landscaped deck connections between dwellings and the shops and other neighborhood facilities. Pedestrian access throughout the project

is uninterrupted by streets since vehicular movement is either under the deck or at its outer periphery.

C.B.D. number 1 Project, comprising the proposed redevelopment of the southern part of "skid row" makes even greater use of the deck idea. Uses proposed for this project include an office area and an "International Center" containing motels, shops, and restaurants oriented to the nearby Civic Center convention area. Parking requirements for the office area vary depending on location and size of parcels. Adjacent to the municipal parking garage, where the street pattern reduces parcels to one or two acres, no parking requirements are included in the restrictions. Land located within the loop boulevard, yet farther away from the municipal garage, is required to have at least one parking space for each 1,000 square feet of gross floor area.

In the larger land area (ten acres) adjacent to the Lodge Expressway, parking is required at the rate of at least one parking space for each 500 square feet of gross floor area. This requirement recognizes the fact that approximately forty percent of persons presently coming to the central business district drive.

At the maximum allowable density and at the rate of one parking space for each 500 square feet, the parking would require full utilization of the land with a two-story parking deck.

The parking requirement in the motel area is one space per motel unit.

In the C.B.D. number 1 Project the deck is used to even greater advantage. Here the deck would not only cover parking but would bridge traffic arteries on a level equal to the deck level, thus continuous, unbroken pedestrian circulation would be available. With the deck being developed throughout most of the project, "first floor" uses would be developed on the deck and all pedestrian activity take place on the deck. It appears that the deck concept would be equally appropriate in the office area and the motel area. Further, the deck pattern in this project could be integrated with the decks in C.B.D. number 2 Project and in the Convention Mall.

The declaration of restrictions prepared by the plan commission as part of the Redevelopment Plan for C.B.D. number 1 and C.B.D. number 2 contained the regulation that all required parking be provided in structures. With the assumption that structure park-

ing must be made financially palatable to the developer, the restrictions allowed greater intensities of development where appropriate.

For example, in the motel area, all parking would take place in the structure, thus freeing the deck for buildings and landscaping. Since a motel unit takes approximately the same space as a parking space, including its portion of the drive, the permitted density could be doubled. Thus, the normal motel density of ninety units an acre was replaced by a limit of 180 units per acre.

The city is leading the way in setting an example for providing parking structures. Besides the underground facilities in Grand Circus Park, an open deck garage and several more proposed facilities, the Civic Center is providing structure parking for approximately 3,000 automobiles. Already in use are the underground garages at the Ford Auditorium and the Veterans Memorial Building. The Cobo Convention Hall and Exhibits Building under construction will provide parking underground and on the roof. The cost of these parking facilities in the Civic Center will be approximately $6,000,000.

It is recognized by the city plan commission that the land-use pattern in the downtown area must be changed to keep pace with contemporary needs and to meet anticipated future demands. Basic to this is a sound traffic system prepared on a comprehensive level and taking into consideration the way in which each phase of the plan will influence and be influenced by other phases.

With the knowledge of these facts, a planning concept must be developed consistent with the great expectations for the future of downtown Detroit by planners and other technicians, and by business and civic leaders who have the courage, wisdom, persistence, and patience to transform these expectations into reality.

Lighting the Connecticut Turnpike

NEWMAN E. ARGRAVES

*Mr. Argraves is the State Highway Commissioner of Connecticut. For eleven years prior to his appointment as Commissioner in 1955, he was a partner in Newman E. Argraves and Associates, serving as General Manager and Chief Engineer in planning, design and supervision of construction of roads, bridges, highways, water works, power plants, wharfs, piers, stadiums and other facilities both in North and South America. From 1926 to 1944, Mr. Argraves was engaged in engineering projects for various private firms and for the Boston and Maine, and New Haven railroads in charge of design as field and resident engineer. He is a Registered Land Surveyor in Connecticut, and a Registered Professional Engineer in Connecticut, California, New Jersey, New York, and Pennsylvania. He is a member of the National Society of Professional Engineers, The American Society of Civil Engineers, and of the Connecticut Board of Registration of Professional Engineers and Land Surveyors.**

THE lights were turned on for the country's longest section of urban and suburban expressway on August 25, 1958. This comprises the westerly fifty-three miles of the 129-mile Connecticut Turnpike and extends from the New York State line at Greenwich to the town of Branford.

The mileage does not include the additional lighting for interchange points east of Branford. Work on these was begun after the August 25 opening of the other section.

The lighting project required extensive testing prior to selection of the extent and type of illumination. This test installation was made on a one-mile section of expressway in the town of Old Lyme, a highway that was already carrying Route U.S. 1 traffic when the test began and was scheduled to serve the Turnpike as well when completed.

Modern concepts of safety indicate a probable need for illumination at interchange points on an expressway such as the Connecticut Turnpike. When the Turnpike tests were begun, little information was available excepting some that covered interchanges at city

*Mr. Argraves recently resigned as Commissioner, effective July 1, 1959.

Figure 1. Overhead destination signs in a lighted area of the Connecticut Turnpike.

Figure 2. Reflectorized signs on unlighted section of the Connecticut Turnpike.

streets. The Connecticut Highway Department had already acquired some experience with lighting at intersections, and a twelve-mile section of the Berlin Turnpike (Routes U.S. 5 and Conn. 15) afforded a basis for some conclusions. The test in Old Lyme provided the information and experience needed to perfect the plans.

Test operations were divided evenly between mercury vapor and fluorescent luminaires on a section of roadway just east of the Raymond E. Baldwin Bridge. Luminaires rated at 20,000 lumens were mounted on poles two hundred feet apart on each side of the roadway and staggered to provide a light source every one hundred feet.

Physical measurements were made and observer reaction evaluated by Wilbur Smith and Associates, consultants on lighting, and by engineer-members of the state highway department. The final selection was based upon these checks and measurements.

Earlier plans called for illuminating the Connecticut Turnpike only at interchanges and other points of possible traffic conflict. The fact that the westerly section of the route had fifty interchanges on fifty-three miles of roadway, in addition to toll plazas and service areas, made it obvious that in many sections the lighting would overlap. Also, adjacent street lights and general illumination in urban areas would leave exceedingly short stretches of darkness. It was recognized that considerable danger would be present with abrupt changes from bright illumination to headlights alone.

The constant adaptation required of the eyes of drivers moving between these lighted and dark sections would have induced additional fatigue and hence increased the danger factor.

Because fixed continuous highway lighting in this busy section would reduce the glare of headlights from opposing lanes, as well as confusion with adjacent lighting, it was decided to install the continuous lighting system from Greenwich to Branford. Traffic forecasts for the remainder of the Connecticut Turnpike between Branford and the Rhode Island state line at Killingly made it obvious that continuous lighting would not be required there at this time.

Lighting Tested for Eye Effects

It is not necessary to recapitulate all details of the engineering analysis made in the test installation, although some of the facts

are interesting. The actual test strip consisted of twenty-seven fluorescent and twenty-two mercury vapor luminaires which made it possible to test both types of luminaires on Portland Cement concrete and dark bituminous surface. Various kinds of checks were made by the lighting consultants using several varieties of instruments.

The eye effect was evaluated at the same time, using three categories of individuals. Group one consisted of experienced lighting engineers. Group two was composed of persons who, while not necessarily familiar with highway lighting design, were briefed on the points to be considered in their evaluation. Group three was made up of persons who not only were probably unfamiliar with the lighting design and installation but who, in addition, were not briefed. Appraisal forms were developed for the use of the three groups, with blanks for all pertinent information.

In the course of analyzing all of the information on the proposed lighting it was determined that fluorescent lighting for the entire fifty-three miles would cost $300,000 more than the same lighting provided by conventional mercury vapor luminaires. This additional expenditure was not justified by the test results, both technical and lay. The department did recognize, however, that further tests were needed with fluorescent lights and it was decided to incorporate an aggregate of seven miles of such lights in the fifty-three mile section. The fluorescent installation is in the Darien-Stamford area.

Earlier in this article it was pointed out that in addition to the fifty-three-mile continuous section of lighting there would be a series of isolated lighting installations at appropriate points east of Branford. With a view to providing comfortable and safe driving conditions through these lighted areas some innovations have been developed in roadway lighting design.

These innovations are aimed at providing a gradual, mounting light-intensity as the driver enters a lighted section, with a decreasing light-intensity as the driver leaves the lighted section. This has been accomplished by starting approximately one thousand feet ahead of an isolated interchange with the installation of two 100-watt lamps. The next two are planned to be 250-watt; the remaining ones in the center of the lighted section will be 400-watt. The same gradation of lighting is provided in reverse in the thousand feet beyond the lighted interchange. It is believed that this gradual transition of light-intensities will greatly reduce fatigue and hazard.

Lighting Variations Aid Drivers

One problem given great consideration was the use of lighting variations to guide the stranger using the Turnpike. With isolated interchanges the problem is not quite as difficult as it is with the continuous lighting. It does, however, exist in both instances. As a means of warning the stranger on the highway and assisting the driver who is familiar with it to find the exit ramps, three amber lights are installed at each point of exit. These specialized lights reduce the danger of rapid movement of traffic from the inside lane to the outside one for the purpose of reaching an exit ramp. The lights will be visible sufficiently far in advance of the exit to permit reasonable weaving. The importance of this safety factor on six- and eight-lane highways cannot be emphasized too much.

The luminaires selected to pinpoint the exit ramps project their light over larger areas than conventional mercury vapor units. Ramp installations on the eastern section of the Turnpike will be composed of directional luminaires with 250-watt lamps.

All luminaires are suspended thirty feet above the outer edge of the pavement with the standards twelve feet from the edge of the pavement. Shoulders are ten feet wide.

The level of illumination averages 0.8 foot-candles on the main line and on ramps where the connecting street level is not lower. Where connecting streets have a lower level the ramp lights are adjusted to meet the local condition.

The toll plazas are lighted with an average of 1.2 foot-candles. Luminaires were installed in an overhead series system to minimize costs.

Overhead destination signs in the light area have their own illumination in the form of fluorescent fixtures at the bottom of each sign. Signs on the Turnpike are reflectorized but in the light area their reflectance value is reduced because most drivers operate with low-beam headlights. If there is light failure, however, the reflectorized signs are there and available with the high beams.

The question has been asked concerning the relationship between lighting and pavement marking. There is none and none is necessary. The basic Connecticut policy of reflectorizing all pavement markings on the state system means that vehicle headlights set off the markings at all times—with or without illumination.

The entire system has been designed to minimize maintenance problems. The overhead wiring is fully available and the use of aluminum poles further simplifies the task. Poles that are struck are generally removed completely, breaking away from the overhead cable. In general, accidents involving aluminum poles are of the property-damage type with almost no personal injuries.

Installation costs for this system averaged approximately $600 per unit or $30,000 a mile. Maintenance and energy costs are estimated at $3,000 per mile, annually.

Research Study Evaluates Results

As this article is being prepared, some four months have elapsed since the lighting system was put into operation on the western section of the Turnpike. During this time considerable research has been carried on by the department in co-operation with the United States Bureau of Public Roads and the Highway Research Board's committee on highway lighting to evaluate the effect of highway illumination on both general highway safety and vehicle operation. The length of the continuously lighted section was the determining factor in selecting the Turnpike for the study.

Completion of all phases of the study will provide answers to many questions that are already being asked. Findings of the study will be available to all interested agencies. Among these questions are those concerning transverse placement of vehicles, operating speed changes, and accidents.

Measurements of vehicle operation were made in daylight, under nighttime conditions prior to turning on the lights, and again under nighttime conditions after lighting installations were in operation. Evaluation of this information is already underway. It is expected to determine the relationship of nighttime traffic operation with and without highway lighting. In addition, it is expected to establish just how closely vehicle operation on a lighted highway conforms to similar operation under daylight conditions. The study includes the accident record of the route, the vehicle placement in marked lanes, and distances between vehicles traveling in the same direction. The study is also concerned with operating speeds and especially with vehicle operation near merging areas at ramp entrances.

Investigations thus far have uncovered generally favorable comment upon the lighting and its attendant benefits. Truck operators who complain of high-beam headlights on unlighted roads have approved the low-beam use that prevails where illumination is provided.

When the lights were first turned on some operators turned off their headlights. The police quickly corrected this practice and all drivers are now using low-beam lights.

Most passenger-car operators who have expressed opinions believe it is less tiring to drive under lights. Some complain about the sense of extreme darkness that prevails after leaving the illuminated section.

The lighting study has been extended by the Bureau of Public Roads to include a survey of driving during the dark period on the New England Thruway in New York State in anticipation of the extension of the lighting from the state line southwesterly.

New Orleans' Seven-Cent Bus Fare

PAUL L. RISTROPH

Mr. Ristroph is Director of the Department of Utilities for the City of New Orleans. His various traffic engineering positions include first Traffic Engineer of New Orleans, Traffic Analyst for the Federal Works Agency, and Traffic Engineer for the New Orleans Public Service Transit Department. He holds an Electrical Engineering degree, and a certificate in Traffic Engineering from Harvard University. During World War II, Mr. Ristroph did traffic research and development work with the Engineer School and the Engineer Board. He is the author of the Staff Officers' Field Manual, "Traffic Circulation and Control." Later, he was in charge of transportation for the Army Headquarters in the Washington, D. C. metropolitan area where he was instrumental in developing transit and other transportation to serve the Pentagon and other military installations. He was twice cited by the Army for this work. Mr. Ristroph is active in affairs of the Institute of Traffic Engineers; he is a past Director of the Institute, and first president of its Southern Section, and a contributor to various technical committees relating to the transit aspects of traffic engineering.

HOW can a city with a population of 602,000 provide an eighteen-mile transit ride for seven cents? What kind of transportation service can be obtained for a fare that is only a fraction of what is paid in other cities? The answers to both of these questions involve many factors, including management and regulatory policies and the characteristics of the community and people being served.

The city of New Orleans has been enjoying a seven-cent transit fare with free transfer privilege since 1922 when the primary mode of transportation was the two-man street car which provided service to a population of about 384,000 persons who averaged about 275 rides per person per year.

Now, the expanded and modernized fleet of 363 buses, 173 trolley coaches, and the remaining eighty-five street cars provides improved service—at the same seven-cent fare with universal

transfer—to more than 327,000 daily riders. Service has been extended until 97 percent of the residents of the city who live on the more densely populated east bank of the Mississippi River are within a walking distance of one-quarter mile from a transit route. Headways are as low as forty-five to sixty seconds on some of the major lines and system speeds average ten miles per hour.

The foundation for this development was laid amid the crumbled and bankrupt lines that provided highly competitive service on routes only three hundred feet apart in some instances. Out of receivership evolved a consolidation of the transit companies operating on the east bank of this old port city. Street railway earnings provided the principal source of revenue although the companies absorbed in the consolidation also furnished manufactured gas and electricity to consumers. All three of the operations—railway, gas, and electric—were consolidated into one company, the present New Orleans Public Service, Inc.

The regulatory agency then as now was the governing body of the city of New Orleans. This body prescribed a system of finance, accounting, and control that has endured in essence since the founding of the new utility company. The supervision exercised by the city through its department of utilities is detailed and thorough. Each route, its extension or abandonment, or the installation of a new route, is controlled by ordinance in conformance with the indeterminate permit issued in 1922.

The first task upon reorganization was to revise transit routes—a gigantic task from the viewpoint of public relations. Yet, the job was done, systematically and step by step, until the routing substantially conformed with the practice later recommended by the Institute of Traffic Engineers in its publication, "Planning of Mass Transit Routes."

Over the period of more than three-score years, the scope of utility service changed. Manufactured gas gave way to the more abundant and cheaper natural gas, which likewise replaced coal as a fuel source. Production and use of electricity increased many fold. Transit usage, on the contrary, declined in patronage despite continued modernization and improvement. It could not withstand the inroads made by the convenience and attractiveness of the automobile. The net result is that the street railway business, once the titan, is now in third place behind the electric and gas business.

Transit Provides Improved Service

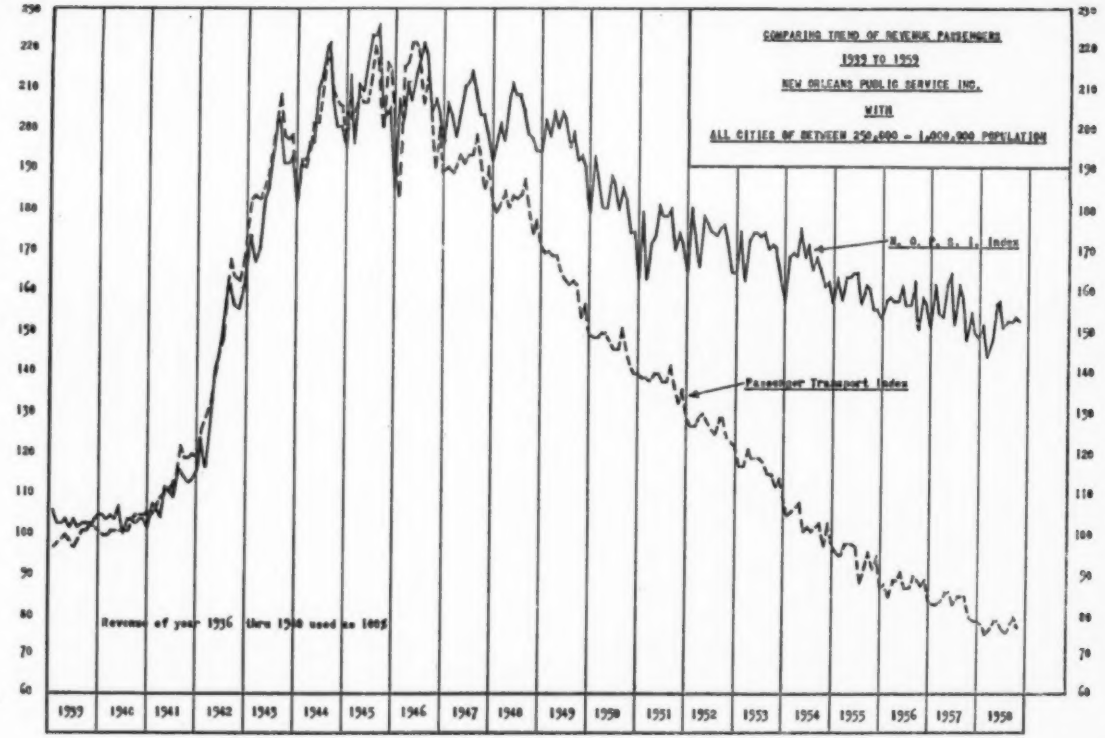
Although outstripped by its contemporaries, transit has continued to provide improved service. In 1922 the system consisted of 271 route miles of streetcar operation. Through consolidation and conversion to coach operations, this streetcar route mileage was reduced to 197 miles by 1930. Growth of the city demanded extension of service and at this time 621 vehicles—all modern except for a few remaining well-maintained streetcars—are operating over 340 route miles.

As the system was extended to newly developed areas on the basis of the same flat fare, the average length of rides increased and, consequently, the number of passengers *per mile* decreased—thus depressing the revenue *per mile*. At the same time, costs increased; and the economies gained through consolidations, alert management techniques, improved equipment, and labor savings realized by the changeover to one-man operation were soon absorbed with the result that each ride cost more to produce.

Ordinarily such a situation can be met only by further reduction in costs through curtailed service, or by an increase in fares. Both of these measures decrease patronage and promote the use of private transportation. The resultant effect is a decline in transit-service use and increased use of private vehicles accompanied by traffic congestion and demands for costly street and parking facilities.

The solution to this problem was not brought about by a "stroke of genius" or by a brilliant decision; rather, a solution evolved through a combination of circumstances in which public opinion played a prominent role. Three factors were primarily responsible: (a) skillful management of the company and its effective regulation by the local government; (b) development of near-by, low-cost natural gas resources and the efficient use of gas both as a fuel and as a lower-cost element in the production of electricity; and, finally, (c) the public's desire for a high standard of transit service without fare increase.

The corporate structure of the company and the regulations prescribed by the city are such that the earnings of the electric, gas, and transit departments are lumped together to determine the



The transit-riding trend in New Orleans compared with that of the United States.

overall earnings of the company. These combined earnings are then related to the company's total investment for all of its facilities (overall rate base) to determine the rate of return. In this manner it is not necessary for each department to show a return, but necessary only that the combined earnings provide a reasonable return on the stockholders' investment.

The return is bolstered primarily by the earnings derived from the electrical department. As the use of electricity increased and as more efficient gas-fired generators were installed—together with sound engineering practices—the unit cost of generating electricity decreased to such an extent that rates were actually reduced.

Thus, while the cost of providing a transit ride was gradually increasing, the cost of producing electricity was gradually decreasing until the losses of transit were largely offset by the revenue from the expanded electrical and gas operations of the company. This combination made unnecessary an increase in transit fares and permitted not only the maintenance of a high level of service but its expansion into outlying areas.

Requests of Public Heeded

The public became accustomed to high quality transit service, and was helpful in pointing out need for extending the service, while at the same time asking for no increase in fares. Since the company was on a sound financial basis, the request of the public regarding low fare was heeded by the company and the regulatory authorities.

A margin of earnings by the electric and gas departments, which makes possible the continued operation of the transit department, is not due to high rates in the utility departments. Rather, the margin is traceable to efficient management, coupled with the relatively low cost of natural gas fuel supply. Comparison of the annual cost of electric, gas, and transit services in New Orleans, computed at rates prevailing in cities with populations ranging between three hundred thousand and one million, shows New Orleans to be lowest of all these cities.

What, then, has been the effect of maintaining a high level transit service coupled with admittedly low fares? This is probably best shown by relating the transit-riding statistics of New Orleans

to the same statistics for the industry as a whole. The acompanying graph shows the transit-riding trend of New Orleans compared with that of the nation. From this it can be seen that since World War II there has been a drop of 55 percent in transit riding on a national basis while the drop has been limited to 24 percent in New Orleans—less than one-half of the average loss experienced by the nation as a whole.

Results, however, are not measured merely by statistics. Their impact upon the economy and welfare of the community is less tangible but more meaningful. The policy of maintaining a high standard of service at a low rate of fare has undoubtedly been responsible for many individuals' continuing to use transit service. The service meets the needs of these people.

Moreover, since these retained passengers are carried in efficient transit vehicles instead of individual passenger cars with a loading factor of 1.58 passengers per vehicle, there is less demand for street, highway, and parking facilities and less traffic congestion than would otherwise prevail. The tax-payer is spared the cost of expensive facilities that would be required to accommodate the great number of persons who now find that mass transit meets their needs.

Traffic Engineering in Public Works

GEORGE J. FISHER

Mr. Fisher is Director of Public Works at Omaha, Nebraska. Previously he was Director of Service (Public Works) at Wichita, Kansas; Traffic Engineer at Oak Ridge, Tennessee; Design and Traffic Engineer for the Ohio Department of Highways, and W.P.A. Area Engineer.

THE traffic engineering section of any city, county, metropolitan area or state is an operating division of government to provide safe, congestion-free streets for citizens, their friends, relatives, visitors, and customers. This traffic division should be located in a branch of government where it can be associated closely with other service functions, particularly those dealing with streets, alleys, sidewalks, and other traffic facilities.

As the community increases, the importance and scope of traffic engineering increase. In smaller communities, the city engineer or one of his assistants can design, install, and maintain necessary traffic control devices. In counties of low population, the county engineer or county surveyor can assume those duties.

In cities of between 50,000 and 100,000 population, the functions of traffic engineering become great enough to assign an engineer to traffic alone. It is best to employ a trained traffic engineer, yet often the city or county does not have the necessary funds. The duties should then be assigned to a qualified engineer in the engineering department. The maintenance of traffic control devices in this case might be done by the street maintenance division, or the county road maintenance division.

In cities of from 100,000 to 500,000 population, the traffic engineering function should be located in the public works department that should operate the street system. In this department, the city traffic engineer becomes associated with street construction, sidewalk construction, expressway design and construction and such other traffic facilities as may become his duty to operate at a later time. *Never* should a traffic engineering function be located in the police department; it is not an enforcement function.

In cities of over 500,000 population, the functions of the traffic engineer and his assistants become so extensive that he should direct a separate traffic department. Many large cities have established separate traffic engineering departments; some have organized street transportation departments that include not only traffic engineering but the design of roads, bridges, expressways and other traffic facilities.

Public Works Related to Traffic Engineering

1. *Airfields and Airports*: Not many cities include the design and construction of airfields and airports as functions of the public works department. Nevertheless, the traffic engineer can assist tremendously in airport design because the traffic system for motor vehicles must function efficiently. Besides traffic circulation, parking lots around airports should be properly designed. Those designs should be checked by the traffic engineer, experienced in this type of facility. The layout of the parking areas, their relationship with entrances to the airport building, and parking operation are a traffic engineering function.

If airfields and airports are operated by the public works department, a co-ordination with the traffic engineer, particularly in design phases, is highly desirable. The traffic engineer can help in determining the required capacity of the traffic distribution system. He can expand traffic counts, study an origin and destination survey, and co-operate with the city planner on future growth patterns of the city.

2. *Bridges*: The design, construction and maintenance of bridges in any governmental unit is an important public works function. It is important to have the traffic engineer close at hand particularly in the design of this traffic facility. Often in the past bridges have been built without much future planning. That is one reason for so many narrow bridges.

The traffic engineer and his knowledge of future traffic volumes should assist in designing bridges of adequate width, of designing proper approaches to those bridges and in the selection of a typical cross section that will accommodate traffic not only for the present

Cf. *Special Report No. 20*, titled "Municipal Public Works Organizations," published by the American Public Works Association, November, 1955.

but for the future as well. This is particularly important in these days of interstate highway construction in which bridges are vital components to limited access design, grade separations, interchanges and traffic distributors.

3. *Buildings*: In those cities where public works departments handle buildings, the functions usually include building inspection, public building design, public building construction and public building maintenance. In public building design, the traffic engineer is an important cog with respect to access to the building and the parking facilities around it. If the traffic engineer and the design, construction and maintenance of public buildings are both in the public works department, the co-ordination can be close.

With regard to general building inspection, the traffic engineer can be very helpful to the inspectors particularly with regard to advertising sign location, curb cuts for driveways and any use of public property during construction that might interfere with vehicular and pedestrian traffic movement.

4. *Engineering—General*: Surveying and mapping—two public works functions—produce results that a traffic engineer can use whether he is in the public works department or not. In reviewing subdivision plats, the traffic engineer should, by all means, be called upon. Often developers design unsafe intersections or intersections having five, six, or seven entrances, or lay out and dedicate rights-of-way too narrow for building streets needed to carry the traffic.

5. *Park Maintenance*: In small communities, this function may be included in the public works department. In large cities, the park problem is of such magnitude that it has departmental status of its own. However, in Omaha and some other cities, the public works department is responsible for the construction and maintenance of the *roads within the parks*. In this case the traffic engineer can assist in determining by traffic loads the width and physical character of the streets. The traffic engineer is also needed to determine what traffic control is necessary at entrances to parks.

6. *Sewage Treatment Plant Operation*: Though this is often a function of the public works department of all size cities, there is only indirect co-ordination between the operation of this function and the traffic engineer. About the only thing the traffic engineer would be interested in is access to and from the plant and the effect of such access on general traffic operation in the city.

7. *Sewers*: This is a function of almost all public works departments and seldom does the traffic engineer have much to do with the direct operation.

During or in planning the construction of a sewer, whether it be a large one or a small one, the traffic engineer can co-ordinate with the sewer engineers in the establishment of detours and the rerouting of traffic during construction. The same applies during the maintenance of sewers in the city whenever the maintenance operation requires the cutting of street pavements or the utilization of street right-of-way. The traffic engineer is always a handy man to have around when planning and designing construction projects of any kind.

8. *Sidewalks*: The public works department in almost all the cities has charge of the planning, design, construction and maintenance of sidewalks. The traffic engineer gets into this problem very deeply with regard to the planning and designing of the sidewalk facilities. He gets involved simply because one of his responsibilities is the provision of safe facilities for school children in going to and from school. Of course he is also interested in the general safety of pedestrians and sidewalks definitely provide for this safety. Often the traffic engineer is called upon to decide what width of sidewalk is needed in business districts or commercial areas when streets need to be widened or reconstructed.

9. *Streets*: Again, one of the principal functions of any public works department is the operation of the street system of the city. In this respect, the engineers in the public works department have to plan, design, construct, maintain and clean the streets and regulate the cutting of the pavements in the street system. Efficient administration of this function necessitates the assistance of the city traffic engineer. The traffic data he collects are paramount to good planning and design; his advice and judgment are necessary for the adoption of widths and detours for construction and reconstruction. His judgment is needed to determine where curb cuts are necessary, how many there should be and how wide each should extend along the curb. Co-ordination should be very close between the traffic engineer and the street engineers of a public works department. As far as maintenance and cleaning of the street system is concerned, the traffic engineer is not so necessary except perhaps for setting up priorities in cleaning operations and snow removal with respect to traffic loads.

10. *Street Lighting*: In a great many cities, the traffic engineer handles the street lighting function and wherever the traffic engineer is located, this function should also be located. Because of his knowledge of traffic loads, accident experience, and street lighting standards, he is the logical one to handle this function. Because it is so advisable for the traffic engineer to be located in the public works department, it is likewise necessary for this function to be located there also so the traffic engineer can handle it.

11. *Traffic Engineering*: This function is responsible for the erection of street-name signs; installation and maintenance of traffic signs and markings; planning, design and operation of off-street parking facilities; design, installation and maintenance of traffic signals; installation, maintenance and operation of parking meters and traffic engineering in general. There is no need to elaborate further on his co-ordination with other functions and sections of a public works department because it is brought out in the discussion of each of the individual functions listed herein.

12. *Street Tree Care*: The traffic engineer can indirectly help here by knowing traffic loads, times of day during which any particular street might have a peak traffic load on it and other such helps.

13. *Water*: Many large and small public works departments of the country handle the water distribution and water plant design, construction and operation. Here again the co-ordination needed with the traffic engineering section or division of such a department is not outstanding but only indirect. In this instance, as in many others, the traffic engineer is a very handy man to have around in the department, just in case problems concerning traffic flow and congestion need to be solved in connection with any part of water distribution or plant operation.

For the greatest advantage to the taxpayer, it appears that the functions of traffic engineering can and should be co-ordinated with other functions of public works departments. Sometimes there are problems in connection with this co-ordination and often it is believed that perhaps the traffic engineering division could function better somewhere else; but in the over-all consideration the traffic engineer's place is with the other trained engineers of the city in the public works department.

There are always administrative problems of personality difficulties, division jealousy, the usurpation of responsibilities and

other deterrents which every administrator must meet in rounding out the operation of the public works department and in getting maximum co-ordination between the various divisions and functions thereof.

If the traffic engineer or if the head of any other division or section of the public works department does not hold up his portion of the work of the department or, for that matter, any particular project, the whole operation will be inefficient.

Urban Renewal and Transportation

WILLIAM H. CLAIRE

Mr. Claire is Assistant Executive Director of the Community Redevelopment Agency of the City of Los Angeles. His professional work was largely with consulting engineers and architects in the Midwest, Rocky Mountain area, and Los Angeles area before joining the staff of the Redevelopment Agency in 1951. Mr. Claire holds a B.S. degree in Architectural Engineering. He is a member of the Los Angeles Urban Renewal Co-ordinating Committee, the advisory council of the Senior Citizens Association of Southern California, and chairman of the Committee on Urban Renewal of the City Planning Division of the American Society of Civil Engineers.

URBAN renewal offers real hope in the solution of many problems of living and working in a city. The list of assists that urban renewal can give to both public and private endeavors is continuously growing. Besides the general benefits of improving public health, promoting traffic safety, reducing the cost of city services, and expanding the tax base, there is another particular benefit—the benefit of urban renewal to urban transportation, and vice versa.

One far-reaching good that comes from urban renewal where federal financing from the Housing and Home Finance Agency (HHFA) is used is that federal loans and grants are available only to those communities, large or small, which have or guarantee to formulate a general or master plan.[1]

The parts required to be included in the general plan are land use, urban renewal, schools, recreation, public facilities, utilities, and urban transportation plans among others. The urban transportation plan should be an integrated system of highways, arterial streets, transit, and parking structures co-ordinated with air, water, and railway lines and terminals for efficient, safe, and fast movement of people and goods at reasonable cost.

1. This is one of seven important points in a Workable Program for Urban Renewal required by the HHFA as follows: Adequate codes and ordinances, comprehensive community plan, neighborhood analysis, administrative organization, financing ability, relocation program, and citizen participation.

General Plan of Urban Renewal

The urban renewal master plan should show the distribution of substandard housing and other conditions of blight throughout the city; a plan of correction of these conditions through redevelopment of obsolete areas too deteriorated for feasible rehabilitation; the rehabilitation of areas worth salvaging, and conservation of the areas where blight is just beginning.

Bringing the urban transportation plan and the urban renewal plan together into the general plan points up the many instances where the two are related and can implement each other. For example, parking structures can be part of an urban renewal project and supply a critical need in an area close to a central business district. The Bunker Hill Urban Renewal Project in Los Angeles is an excellent example of this.

The parking structures proposed in this area will help supply the need in the adjacent civic center and central business district as well as in the project area. Figure 1 is an aerial photo showing the relationship of the Bunker Hill project to the downtown vicinity of Los Angeles. The city council passed an ordinance approving the redevelopment plan for the project on March 31, 1959.

The residential land-use part of a general plan for a city is the basis for a comprehensive housing plan for the community. Eventually, logic leads planners and engineers to the conclusion that a housing plan is just as much a requirement for orderly growth as a master plan of streets or schools. The housing plan would show densities of residential development, price and types of houses or apartments, areas still to be developed and residential land to be made available through urban renewal. Here are some of the reasons a housing plan is important to urban renewal and urban transportation:

1. A plan for relocation of site occupants displaced by urban renewal and other governmental action can be more intelligently formulated and more effectively carried out.

2. Selection of the type of residential land reuse in an urban renewal project can be more accurately made in relation to adjacent areas.

3. Builders and developers taking advantage of FHA Sections

220 and 221 mortgage insurance can do so with assurance of a sound investment and successful enterprise.

4. Size and spacing of arterial highway routes can be planned for a predetermined traffic load.

5. Rapid mass transit routes can be planned and installed to serve residential areas of known densities.

6. Population densities can be planned to help justify the cost of rapid mass transit.

Urban renewal projects afford the traffic engineer an excellent opportunity to develop a workable arterial street system by connecting missing links in arterial routes and widening or realigning streets. In industrial land-reuse projects a particular opportunity is available to eliminate unnecessary minor streets—many of which are substandard as industrial traffic carriers—and to convert such street-areas to useful industrial purposes.

This is especially true where substandard residential land use is mixed in with factories and where the factories desperately need land for expansion. The area in the streets used for residential purposes is vacated for industrial use as the residential properties are acquired through redevelopment, and a substantial addition to the tax base of the community results.

Capital Improvements Program

The general plan for a community, if working effectively, is the basis for the community's capital improvement program. This is the list of improvements necessary in highways, parks, traffic facilities, schools, public buildings, and the long list of items the modern city, large or small, is called upon to furnish its people as services. Paradoxically, the demand for these items is about as loud and insistent as the objections to taxes to pay for them. Urban renewal can help in this dilemma.

The redevelopment of areas too substandard to rehabilitate requires acquisition, relocation of site occupants, demolition, preparation of the site for new uses, and disposition of the cleared land, usually to private enterprise. This process requires a write-down in that buying land and buildings (their age and condition, notwithstanding, the buildings still have a market value), demolishing the buildings, and preparing the site by grading and street and

Community Redevelopment Agency of the City of Los Angeles

Figure 1. Bunker Hill project in relation to Civic Center and Central Business District.

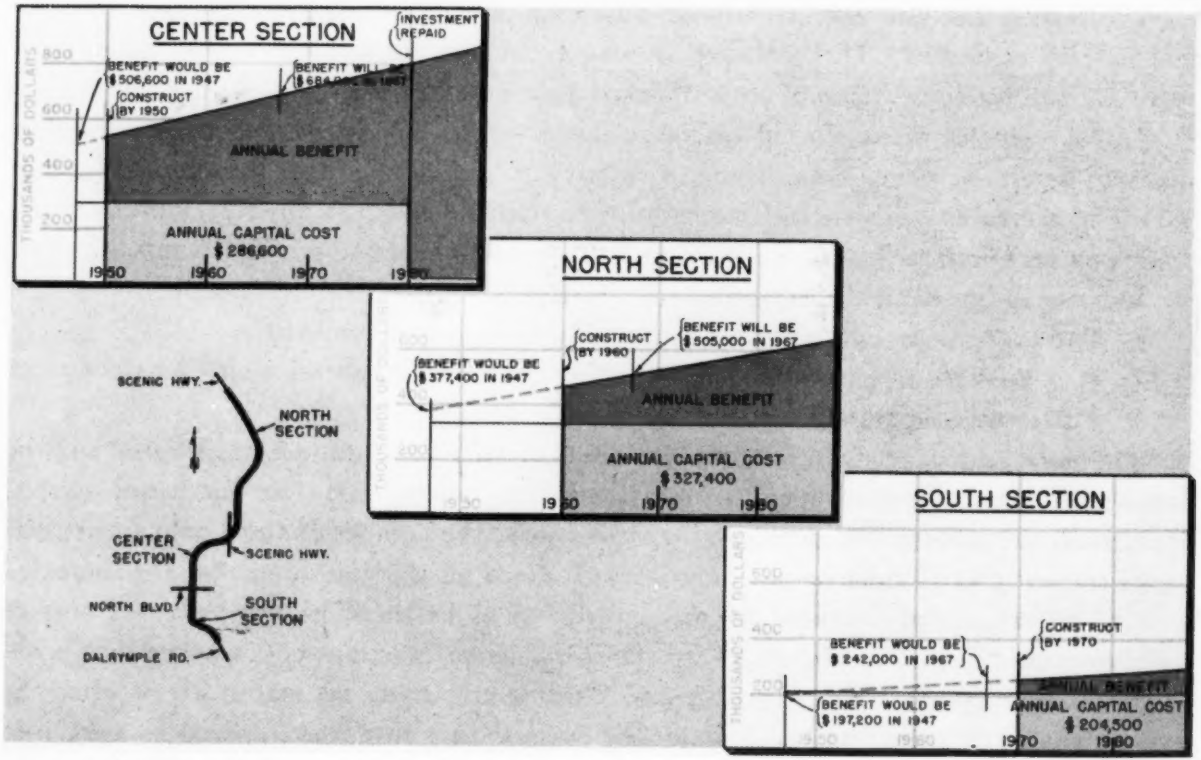


Figure 2. Graphic comparison of benefits and cost of a proposed Baton Rouge Expressway.

utility changes, usually cost more than can be obtained from the proceeds of land disposition.

Two-thirds of this write-down, or net project cost, may be a federal grant-in-aid and the other one-third is the local share. This local share may be in a cash form or in improvements that benefit the project area. If the latter, they are called non-cash grants-in-aid. The people of the city, therefore, regain two of their federal tax dollars for every dollar spent on non-cash grants-in-aid.

The capital improvement program should be carefully studied for improvements that can count as non-cash grants-in-aid in urban renewal projects. Since the city is proposing the work, anyway, it may feasibly be moved forward or backward in priority, if necessary, in the capital improvement program and fitted into the financial plan of the urban renewal project.

If the work does not fit geographically or time-wise into the urban renewal project, the city still has a responsibility to develop the local one-third share of the net project cost through appropriation, general obligation bond issue, or a tax allocation bond issue as provided for in the California Constitution. This method allows an urban renewal agency to use the increase in tax revenue as a result of redevelopment to defray net project costs. After these costs are repaid, the entire tax revenue, including the increase, goes to the normal taxing bodies.

Freeways and Renewal

Another opportunity for bringing about better urban transportation through urban renewal is in connection with freeways or expressways. If the freeway is already in place and passes through a blighted area, urban renewal can free this type of land through redevelopment for higher and better uses. Deteriorated structures, neglect, absentee ownership, and outmoded street patterns are characteristic of such areas.

The Bunker Hill Urban Renewal Project adjacent to the Harbor and Hollywood Freeways in Los Angeles is a case in point. As the city grows and need for space for modern residential, commercial, or industrial facilities develops, urban renewal can do a double good turn for the community by eliminating costly blight and clearing space for these new private improvements.

While employed by a Chicago consulting firm, the writer worked on comprehensive urban transportation studies of expressways, arterial streets, parking structures, transit systems, trucking routes, terminals, and the like. After an expressway system was planned for a city and a tentative location was determined, based on present and anticipated origin-destination data, each part of the system was subjected to an economic benefit study. The study analyzed the comparison of actual dollar savings to users of the expressway with the cost of that portion of the expressway under study. The results of these studies laid a firm economic basis for the order in which parts of the expressway should be built.

One important factor in a benefit-cost comparison study of an expressway route was the present and anticipated population in the area served by the route. The greater the use of the route, the greater, of course, would be the benefit. Now, urban renewal can accelerate the population increase by clearing unplanned, low-density obsolescence and rebuilding higher-density, but soundly planned, modern development. Figure 2 is an example of the graphic comparison of benefits and costs of the expressway proposed in 1947 for Baton Rouge, Louisiana.

All of us working in urban renewal or freeways are missing many a grand chance by not co-ordinating more closely our freeway and urban renewal plans. We could have better and more strategically located truck terminals, bus terminals, parking structures, transit facilities, air terminals, warehouses and a host of other modern facilities needed to make the city operate more efficiently. In some urban renewal project areas these facilities could help justify the cost of the freeway structure within the project if areas adjacent to the freeway were planned for optimum land use.

The principal reasons we do not take full advantage of this situation are twofold: (1) the freeway builders are under tremendous political pressure to get the freeway routes into operation and (2) urban renewal is a new governmental process that takes time to generate the public support it needs to go forward at the same pace as the freeways.

Another planning technique developed at the Chicago firm was a location of freeways so they would lie between residential neighborhoods rather than pass through them and adversely affect the character and quiet of the neighborhood. This technique is a

necessary part of urban renewal and freeway planning co-ordination. An encouraging sign in this respect is the directive to the Housing and Home Finance Agency and a similar one to the Bureau of Public Roads to insure maximum co-ordination where the two activities of urban renewal projects and highways are being planned or built in the same part of the city.

Much benefit to the city and economy of public funds can come of this. New freeway routes can be so located that they help eliminate substandard housing in an urban renewal area, for example, and the proximity of a proposed or existing freeway can help the marketability of cleared land in an urban renewal project.

The Urban Renewal Administration of the HHFA cites several situations in which urban renewal and highway planning and development are not only desirable but in some instances a necessity. The letter[2] describes how a freeway may cut into a large part of the urban renewal project's eligibility by the elimination of substandard dwelling units and other conditions of blight. The matter of land acquisition in the urban renewal project and the freeway right-of-way must be co-ordinated to maintain fair market values and to insure that neither program will increase the cost of the other.

The timing of land disposition in an urban renewal project should be carefully geared to the highway development so that maximum land value, usually after completion of the highway, can be obtained by the urban renewal agency. Relocation of site occupants from both highway and urban renewal activities can be carried out in an orderly and humanistic manner. The maximum advantage of FHA Sections 220 and 221 mortgage insurance can be realized through co-ordination of relocation activities.

Neighborhood Planning

The optimum effectiveness of urban renewal is obtained by planning the urban renewal project on a neighborhood basis and eliminating the conditions of blight in a whole planning unit, the residential neighborhood. The area encompassed by a neighborhood might be considered an elementary school district with the

2. Local Public Agency Letter 149, July 2, 1958: "Co-ordination with Major Highway Programs."

school logically placed at or near the center of the neighborhood. Arterial streets would best be located at the periphery of the neighborhood to channel through-traffic around rather than across the neighborhood. The main point here is that these arterials should lead to freeway access points and, conversely, the design of the freeway should be such that the on- and off-ramps are lined up with the arterials, which, in turn, are planned with the neighborhood street system.

Often this planning advantage is missed because the freeway location and design are years ahead of the city plan of neighborhoods and arterials, or a community is not sufficiently sold on planning to formulate a general plan of land use. Frequently, the result is a series of traffic-congestion points at or near on- and off-ramps of freeways where the arterials are not designed to cope with traffic volumes generated by the area served.

Also important is the location of the freeway so that it too, as well as the arterials, traverses the periphery of neighborhoods instead of carrying large volumes of traffic through good residential areas. This principle has all too often been ignored in location of freeways. The highway engineer may not have been properly impressed with the value of this principle. The city planner may have been too involved in the avalanche of zoning and planning details to formulate a master plan of land use co-ordinated with a master plan of highways. The mayor or governor or business organizations may have lost patience in getting the freeway built and arranged to go ahead with construction without waiting for planning "perfections."

But gradually the planning required for urban renewal bears out the necessity and logic of these principles and the convenience and economy to be gained thereby. Where this applies to a freeway in a metropolis, it also may apply in a small city to a modified expressway or arterial route.

Effect on Land Economics

A pattern of land-value fluctuation takes place at or near a freeway, often in this manner: (1) the freeway route is adopted, right-of-way acquisition begins, and some property owners near the right-of-way sell out to speculators at low, panic prices; (2)

Leonard Nadel, Photographer, Los Angeles

Figure 3. The Harbor Freeway in Los Angeles, showing deterioration proposed for redevelopment.

freeway construction starts and the dirt and noise and commotion cause others nearby to sell below market value; (3) the freeway is finally completed, the dust clears away and, where possible, a higher intensity of land use develops and property values not only return to normal but in some sections increase to take advantage of the convenience afforded by the freeway.

This is an over-simplification, true, since other factors act on the value of that same land. The distance from the freeway is important to land value for some properties. Light sleepers are bothered by the freeway if trucks are permitted on it, for instance. The freeway may be elevated and cut off a view from certain properties. General economic conditions in the area may have a greater influence on property values than the freeway produces.

However, these facts notwithstanding, the natural development of the area near the freeway to capitalize on the time-saving and ease of travel on the freeway is arrested by existing development and here is where urban renewal can correct this economic stagnation, if the existing development is substandard or blighted. This is illustrated in Figure 3, showing the Harbor Freeway just south of the "stack" (four-level interchange) in Los Angeles. On each side are obsolescent and dilapidated buildings, many of which were built in the previous century.

Most of this misuse of land is to be corrected by urban renewal projects proposed on both sides of the freeway. In place of the deterioration shown, modern high-rise and garden-type apartments and office buildings will make full use of the freeway system. The community benefits in this process through a broader tax base and a more efficient city. The businessman benefits in time saved in the conduct of his business. The worker benefits by having a desirable place to live within walking distance of his office or, if he still wants to live in the suburbs, by less strain in getting to or from work on the freeway.

Co-ordinated Planning Essential

Essential to a successful urban renewal program and professionally correct urban renewal project plans, is the close co-ordination the urban renewal agency should maintain with the highway engineer and the traffic engineer. In Los Angeles, the freeway program is moving faster than urban renewal and this

fact is taken into consideration in long range planning. The liaison with the city traffic department has been a boon to the urban renewal project plans in progress.

The new Executive Director of the Community Redevelopment Agency of the City of Los Angeles has vigorously carried on this policy of close co-ordination with other governmental professionals. The effort is rewarding. The latest highway and traffic engineering techniques are thereby available to improve the urban renewal plan.

Can we afford to delay any longer the planning and development of a workable urban transportation system and a workable program of urban renewal? Are we just keeping up with day-to-day demands for freeways and transit facilities without planning for the great need for them in the not-too-distant future? Do we know the real cost of industry's moving away from or avoiding cities that fail or refuse to correct blight and costly traffic delay? Do we know the full cost of subsidizing slums? Are we able to imagine or do we dare to contemplate the traffic congestion ahead of us, if we don't make comprehensive plans now and carry them out in time?

The Hollywood Freeway broke the capacity "barrier" and chalked up 2,225 vehicles per lane per hour. The total vehicle count made by the California Division of Highways on a July, 1958 week-day was 199,795 in 24 hours. Yet the capacity is exceeded at least twice a day and sometimes oftener.

This is a hint of what is ahead in gearing cities to prepare for much greater traffic volumes, to develop higher intensities of land use on a planned basis, to provide a modern, efficient plant for living and working.

We can have freeways exclusively for trucks; we can pipe rather than truck more commodities; we can use conveyor belts for people and goods where justified; we can have fast, rapid mass transit before it is too late; we can build offices and apartments near enough to walk between them and reduce traffic thereby. We can and will do a lot of other necessary jobs to make city life less of a strain and expense. One way to help bring this about is close co-ordination of urban renewal and urban transportation.

The Multiple Regression Method of Forecasting Traffic Volumes

SAM OSOFSKY

Mr. Osofsky is Highway Economist for the California State Division of Highways. He joined the Division in 1934 as a junior statistician and has progressed through the various statistical ratings to his present position. He is a Registered Electrical Engineer, a member of the Institute of Traffic Engineers, the American Statistical Association, and the Western Governmental Research Association.

SINCE the inception of the home interview type of origin and destination survey there have been available objective basic data for study and assignment of traffic to a proposed freeway or freeway system in an urbanized area. The survey data, however, cover only the existing situation—that is, the period of the data collection. For the engineer and planning officials connected with urban development, objective information for the design year, usually at least twenty years or more after the survey, is also needed.

Recent literature has discussed at some length problems of various methods of forecasting design year traffic.[1] Reviewed briefly in this article are two methods in order to note the primary reasons for the development of the regression method.

Fratar Method

Perhaps the first practical solution of the general problem was the Fratar Method.[2] In this method estimates of design year trip ends are made. Then the design year trip ends and the survey interzone trip data are the information the formula utilizes for obtaining interzone traffic volumes for the design year. The formula relates these data in such a way that if the volume between a pair

1. Authors include: Glen E. Brokke, Bureau of Public Roads; A. M. Vorhees, Automotive Safety Foundation; and William B. Calland, California State Division of Highways.
2. "Vehicular Trip Distribution by Successive Approximations," by Thomas J. Fratar, *Traffic Quarterly*, January, 1954.

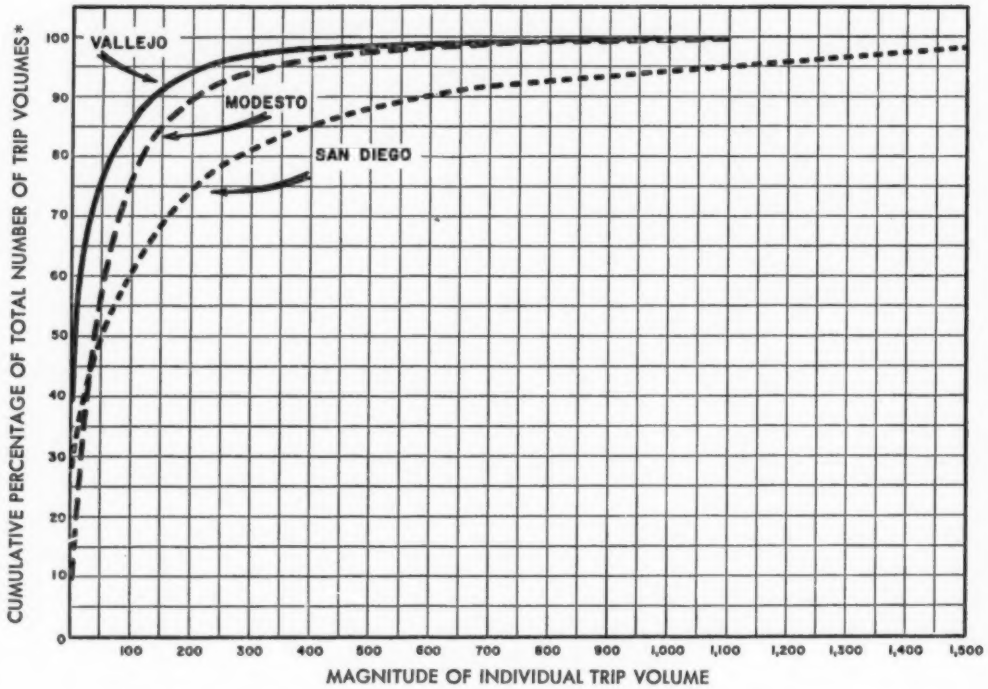


Chart A. Comparison of percentage distributions of the number of trip volumes between pairs of zones (including trip volumes between major cordon stations and zones). Data for San Diego, Modesto, and Vallejo.

* Percentage plotted at upper limit of class interval.

of zones was zero in the survey data, then the design year trip volume is also zero. This can be a serious limitation in the use of the Fratar Method because (as shown on Chart A) the percentage of zero volumes can vary considerably—28 percent for San Diego, 39 percent for Vallejo, and 10 percent for Modesto. Adequate adjustments for this limitation of the Fratar Method are difficult to make.

Gravity Method

The Gravity Method, reported by William B. Calland,[3] introduced a distance factor into the formulas for estimating design year traffic volumes. The Gravity Method solved the problem of estimating all volumes even though the survey value was zero. However, other limitations also suggested the need for further research.

The use of the Gravity Method involves three steps: first, estimate the design year trip ends for each zone; second, estimate the percentage of total origins remaining within each zone and calculate the residual number of trip ends (total trip ends minus intrazone trips); third, apply a formula which utilizes a distance factor and residual trip ends to estimate the design year interzone trips. A different estimating equation is used for trips involving the central business district, and another estimating equation for trips involving cordon stations.

An analysis of the Gravity Method has shown two serious limitations: first, the procedure for obtaining the percentage intrazone figures may lead to unduly high errors; and second, the relationship used to develop a distance factor is also subject to high errors.

The error of estimation for the percentages of intrazone trips is illustrated in Chart B. It is obvious from the chart that the intrazone percentage figures in the density range of 5,000 to 9,999 trips overlap to a considerable extent the smooth curves used to represent other trip densities. The Los Angeles data in particular show that the maximum values on the smooth curves may be too high, at

3. "Traffic Forecasting and Origin and Destination Trip Assignment Techniques," by William B. Calland, presented at the Eleventh Annual Convention of the Western Section, Institute of Traffic Engineers, June, 1958.

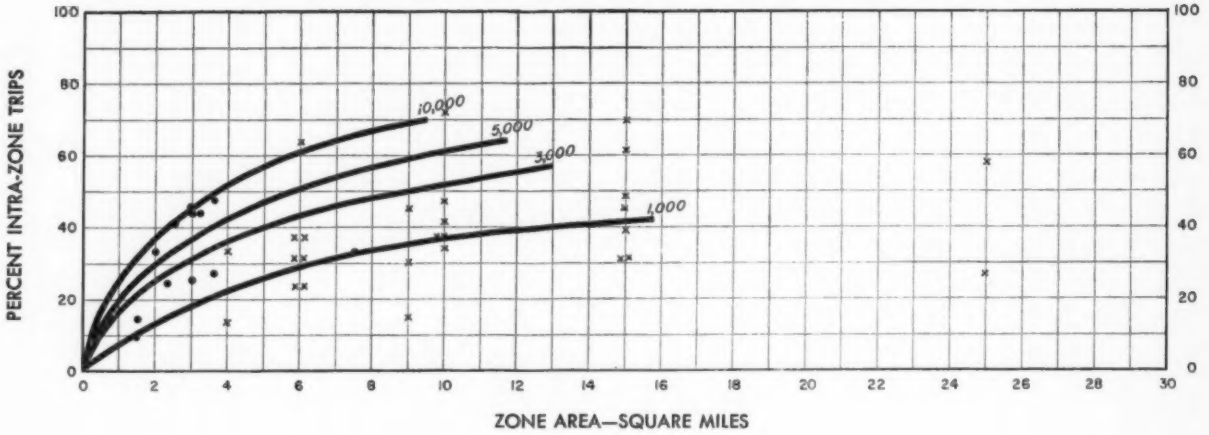


Chart B. "Gravity" method intra-zone trip Estimation Curves. Note: The separate curves are for use with the trip densities indicated. Trip density is determined as follows: Trip Density $= \frac{\text{Origins}}{\text{Square Miles}}$. Plotted points are from zones with trip densities in range 5,000 to 9,999.

• San Diego Study × Los Angeles Study

least in applications of the curves to situations with relatively large zones or to other study areas.

The source of errors of estimation in using relationships between

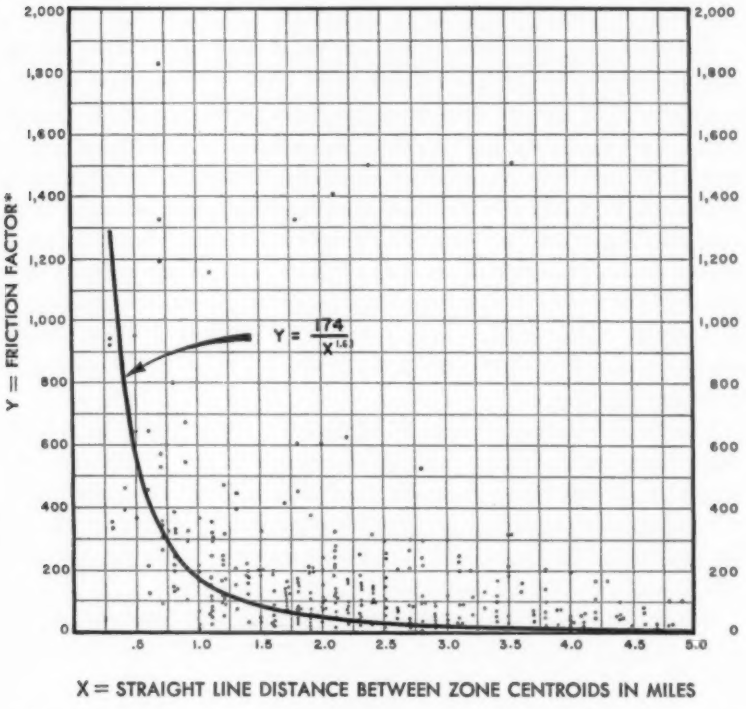


Chart C. "Gravity" Method data for Modesto, comparing inter-zonal friction factors with distances between pairs of Zone Centroids. Note: The curve was determined by a least squares fit to all observations; however, the points plotted are limited to a ten percent (random) sample (*excluding zero values of Y*).

$$\text{*Friction factor} = \left[\frac{\text{Inter-zonal trips}}{(\text{Total origins at Zone A})\,(\text{Total origins at Zone B})}\right] \times 10^7$$

the friction factor (defined by Calland) and the distance between zones is illustrated in Chart C. Many of the extreme variations from the smooth curve in Chart C are undoubtedly due to variations in the characteristics of the individual zones. The essence of the

regression method is the addition of the zone characteristics directly into the formula for calculating estimates of trip volumes.

The Multiple Regression Method

Personnel in the traffic and planning survey sections of the California Division of Highways have been concerned with the development of design year data since the first metropolitan-type origin and destination survey was conducted in California in 1947. The Fratar and the Gravity Methods have been used in California. For some time it has been felt that the multiple regression approach to forecasting traffic volumes between zones might have promise as an improved method. It is only with the recent availability of a medium-size computer and procurement of personnel trained in the needed mathematics and statistics that it has been found possible to do the research needed for development of the multiple regression method.[4]

The validity of the multiple regression method for forecasting design year trip volumes rests on notions that are generally well established. If any objective method of projection is to be developed, the fundamental assumption must be accepted: that the sources that determine the variation among survey trip volumes will remain as valid determining factors for a design year.

If this broad assumption is accepted, then, without any serious doubt, we may assert several corollaries and other logical concepts as they are relevant to the multiple regression method.

A. The trip volumes between one zone and each of the other zones (within the cordon of the metropolitan area) will tend to decrease as distance increases; and the trip volumes will tend to increase as the population of each of the other zones increases. Charts D-1 and D-2 illustrate these assertions. These and similar charts for other zones and for other metropolitan areas also show a wide deviation of the trip values from a line representing the general relationship of increase or decrease. Such general relationships could be represented by linear equations such as the following:

4. The only previous report of this research was made in a paper entitled "A Multiple Regression Approach to Forecasting Urban Area Traffic Volumes" presented by Mr. Sam Osofsky at the American Association of State Highway Officials' meeting in San Francisco. December 2, 1958.

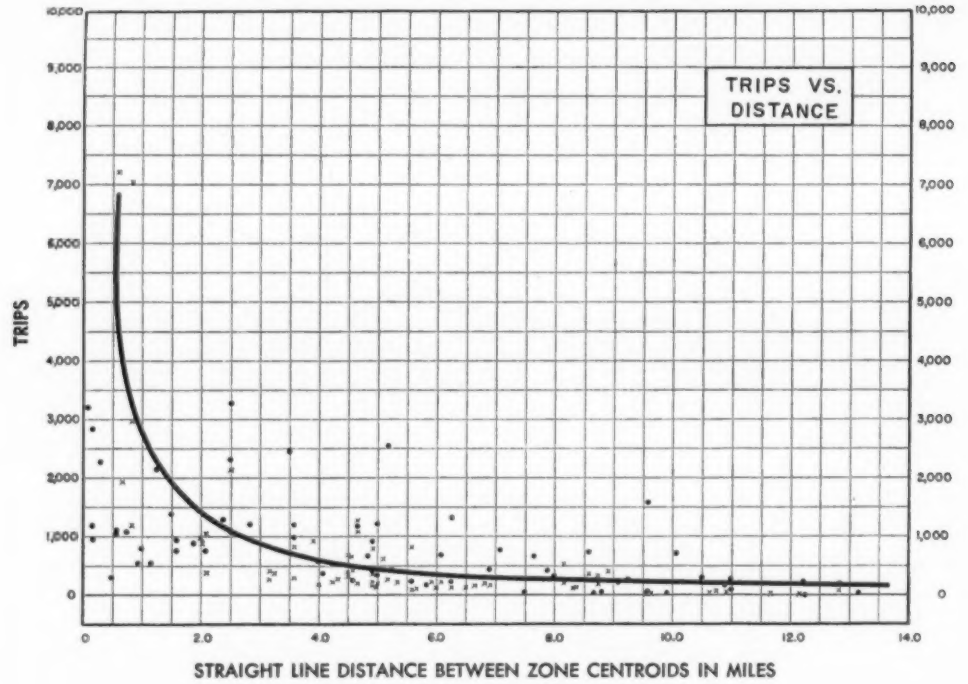


Chart D-1. San Diego inter-zonal data from one zone to all other zones.
Note: The line of relationship is a rough freehand line.

×From Zone 33 ·From Zone 42

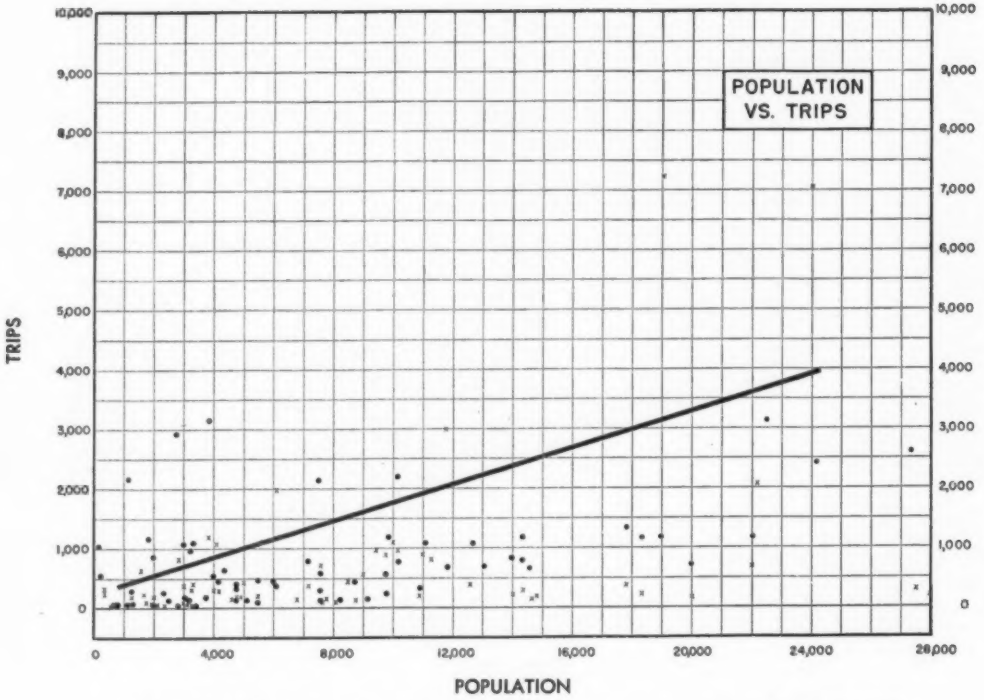


Chart D-2. San Diego inter-zonal data from one zone to all other zones.
Note: The line of relationship is a rough freehand line.

×From Zone 33 ·From Zone 42

$$\text{Trips} = a_1 \text{ (population)} + a_0$$

or

$$\text{Trips} = a_1 \text{ (1 + distance)} + a_0$$

However, detailed regression analyses have demonstrated that the errors of trip estimation from these and similar types of gross regression equations are larger than we care to accept. Considerable reduction in error has been obtained when the joint effect of population and distance was considered. Thus, a better equation is of the following form:

$$\text{Trips} = a_1 \text{ (population + distance)} + a_0$$

B. The trip volumes between one zone and each of the other zones are also generally expected (that is with other factors being held constant) to have the following relationships to trips:

1. Trips increase as vehicles owned increase. See Chart D-3.
2. Trips increase as employed persons increase. See Chart D-4.
3. Trips increase as commercial acreage increases. See Chart E.

C. Other criteria may be considered. To date we have tried to use industrial acreage and indices of land use. We have found that the number of trips will vary with both the character and acreage utilized. In regard to a land-use index, we have attempted to use an index involving trips themselves (origins per person); the relationship was anything but consistent. The final selection of the factors best suited for use in the regression equations depends primarily on three considerations: first, can the factor reasonably be measured or estimated at both the survey period and the design year; second, will the factor logically and consistently contribute to reduction of errors of estimation; third, will the design year estimate based on the factors selected result in reasonable and acceptable estimates of trip volumes?

The third consideration listed above is in many ways the most important and the most difficult problem because some regression equations can (in this special sense) fit the data too well. If this happens, the design year factors may be so far out of range of the comparable values of the factors for the survey period that calculated estimates of trip volumes at the design year may be either absurdly high or low.

All of the factors listed above have been used in our studies of the feasibility of the regression method. Various equations studied

with respect to Modesto, San Diego, and Vallejo will be discussed later.

The multiple regression method involves the following steps:

1. Select an equation form determined from experience and theory. Using trip interchange and independent variable values from the survey data, obtain a set of coefficients relating a specific

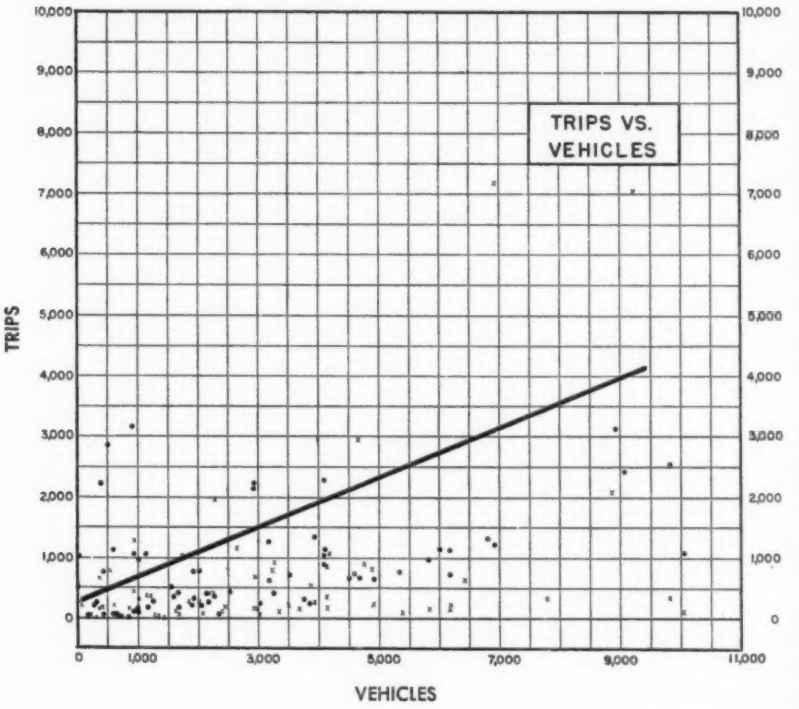


Chart D-3. San Diego inter-zone data from one zone to all other zones. Note: The line of relationship is a rough freehand line.

×From Zone 33 •From Zone 42

single zone to all zones including itself. Repeat this process treating each zone in turn as a specific zone. A different set of coefficients (a_1, a_2, a_3, a_4, and a_0) for each zone and each cordon station is determined.

2. Estimate the theoretical trips at the survey period by using the coefficients and the independent variable values of Step 1.

Then analyze the differences between theoretical and survey trips. Step 1 will be repeated if the analysis warrants modification in equation form.

3. Estimate the independent variables at the design year.

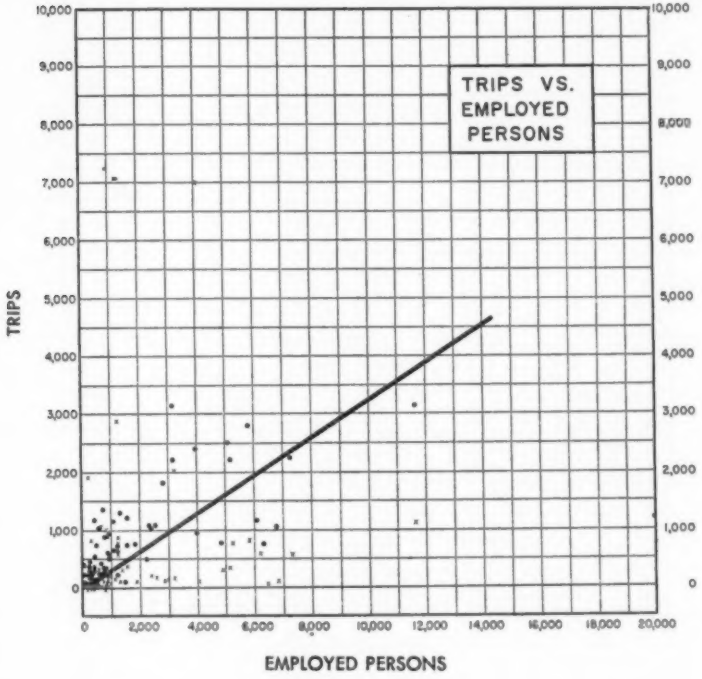


Chart D-4. San Diego inter-zone data from one zone to all other zones. Note: The line of relationship is a rough freehand line.

×From Zone 33 •From Zone 42

4. Use the estimated independent variables at the design year with the coefficients of Step 1 to calculate the theoretical trips at the design year.

It should be noted that in this regression method a single equation form is used for all zones and cordon stations. However, one set of regression coefficients is calculated for each zone and for each cordon station. In this method there will be two estimates of

each volume except for the intrazone and cordon-to-zone volumes. The two estimates are averaged to provide the final interzonal estimate.

It is possible with the multiple regression method to calculate one over-all equation with one set of regression coefficients for all zone-to-zone and intrazone trips; another over-all equation with

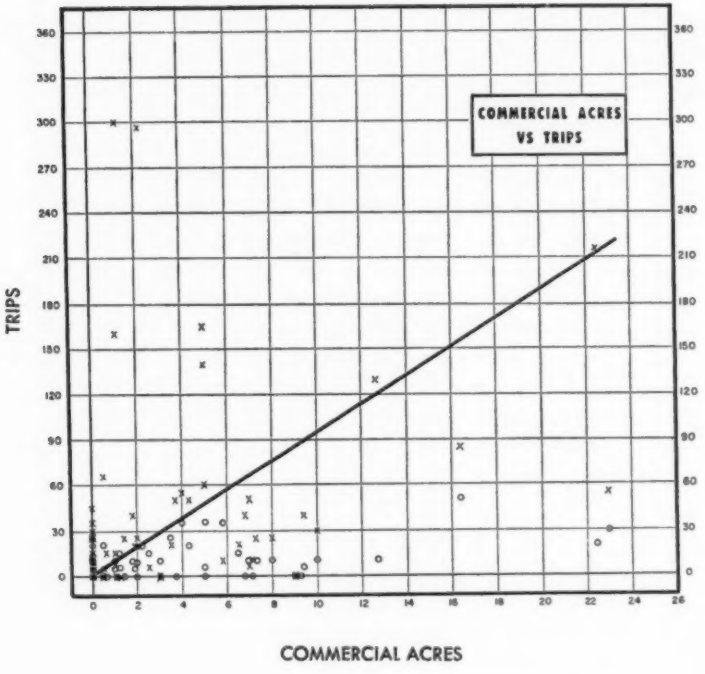


Chart E. Vallejo inter-zone data from one zone to all other zones. Note: The line of relationship is a rough freehand line.

×From Zone 25 •From Zone 61

one set of regression coefficients can be calculated for the cordon station-to-zone trips. This would result in two over-all equations for a study area: one for all zones and one for all cordon stations.

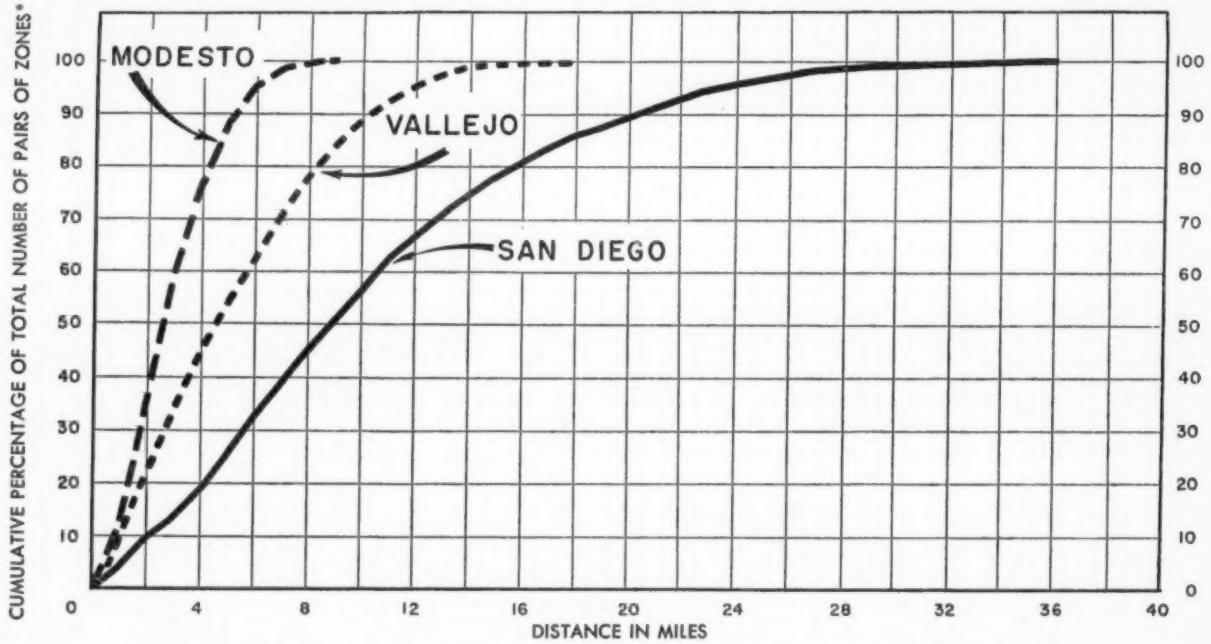


Chart F. Comparison of percentage distribution for distances between pairs of zones (including distances from major cordon stations to zones). Data for Vallejo, Modesto, and San Diego.

*Percentage plotted at upper limit of class interval.

California's Experience

To date the regression method has been applied to the following study areas: Modesto, San Diego, and Vallejo. We shall attempt to carry the reader through the development process of the multiple regression approach as it stands to date.

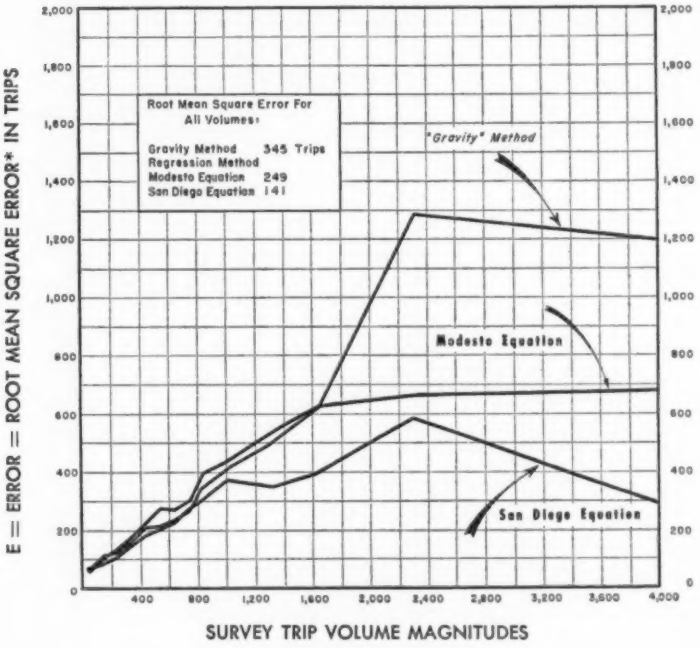

E = ERROR = ROOT MEAN SQUARE ERROR* IN TRIPS
Root Mean Square Error For All Volumes:
Gravity Method 345 Trips
Regression Method
Modesto Equation 249
San Diego Equation 141
"Gravity" Method
Modesto Equation
San Diego Equation
SURVEY TRIP VOLUME MAGNITUDES

Chart G-1. San Diego data; comparison of "Gravity" and "Regression" method estimation errors, by magnitude of survey trip volumes.

*The estimation error is obtained (for each trip volume group) from the sums of the squares of the differences between the survey and theoretical trips for each pair of zones. The sums for each group are divided by the number of pairs of zones in the volume group and the square root of each quotient is the root mean square error of the group.

Symbolically $E = \sqrt{\frac{\Sigma (T-S)^2}{N}}$

Soon after this research was started, it was decided that there would be advantages in using a relatively recent and small survey area. There follows an outline of the experience gained in making

this original research in the Modesto area (population 78,000) as applied subsequently to San Diego (population 580,000) and Vallejo (population 73,000). On Chart I are recorded the equation forms used in each of the above areas.

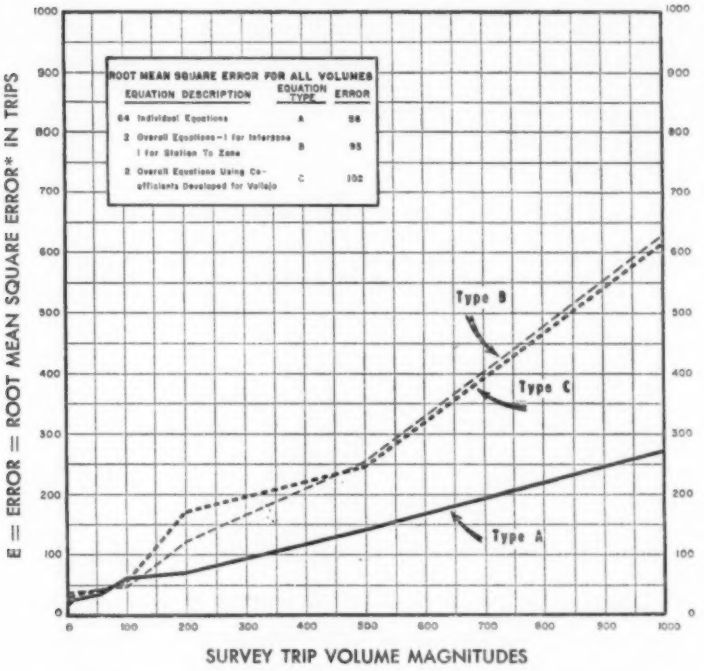


Chart G-2. Modesto Data: Comparison of regression equation estimation errors by magnitude of survey trip volumes.

*The estimation error is obtained (for each trip volume group) from the sums of the squares of the differences between the survey and theoretical trips for each pair of zones. The sums for each group are divided by the number of pairs of zones in the volume group and the square root of each quotient is the root mean square error of the group.
Symbolically $E=\sqrt{\frac{\Sigma(T-S)^2}{N}}$

When the Modesto regression equation was applied to San Diego data, the over-all error was less than for the Gravity Method; but for the low-trip volumes, the Gravity Method generally had smaller errors, as shown on Chart G-1.

An analysis disclosed that the high errors of estimation occurred under two types of situations: first, fairly consistent underestimation

occurred for intrazone or adjacent zone volumes; second, underestimation frequently occurred for large zones of high population. As a result of this analysis, a revision in the method of estimating the distance factor was made. The exponent for distance in the estimating equation was also revised. The resulting equation was

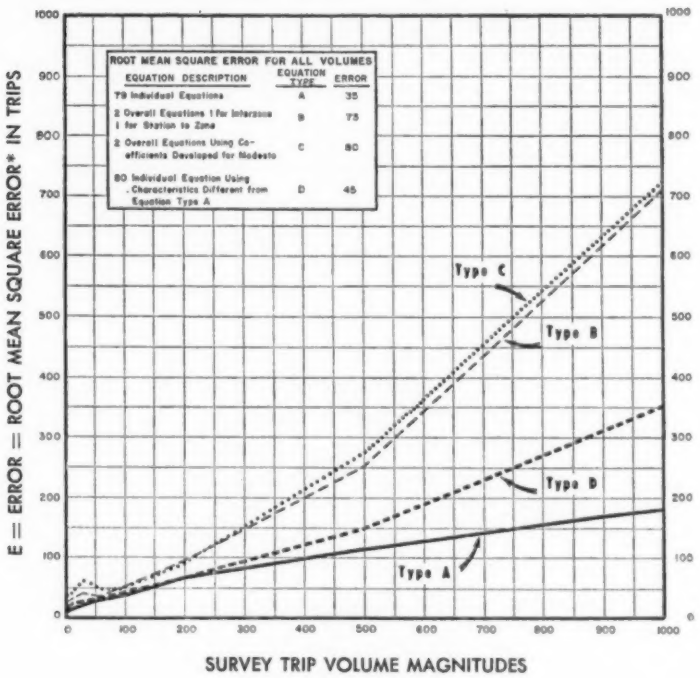


Chart G-3. Vallejo Data: Comparison of regression equation estimation errors by magnitude of survey trip volumes.

*The estimation error is obtained (for each trip volume group) from the sums of the squares of the differences between the survey and theoretical trips for each pair of zones. The sums for each group are divided by the number of pairs of zones in the volume group and the square root of each quotient is the root mean square error of the group.

Symbolically $E=\sqrt{\frac{\Sigma(T-S)^2}{N}}$

the San Diego equation shown on Chart I. After these changes the average error (root mean square error) was only 141 trips as compared to 249 trips for the Modesto regression equation and 350 trips for the Gravity Method.

These results were considered an adequate demonstration that the regression method merited serious consideration as a valid and reliable method for the development of design year trip data.

The results of this research for San Diego were available in time to allow us to use our experience in an actual application in

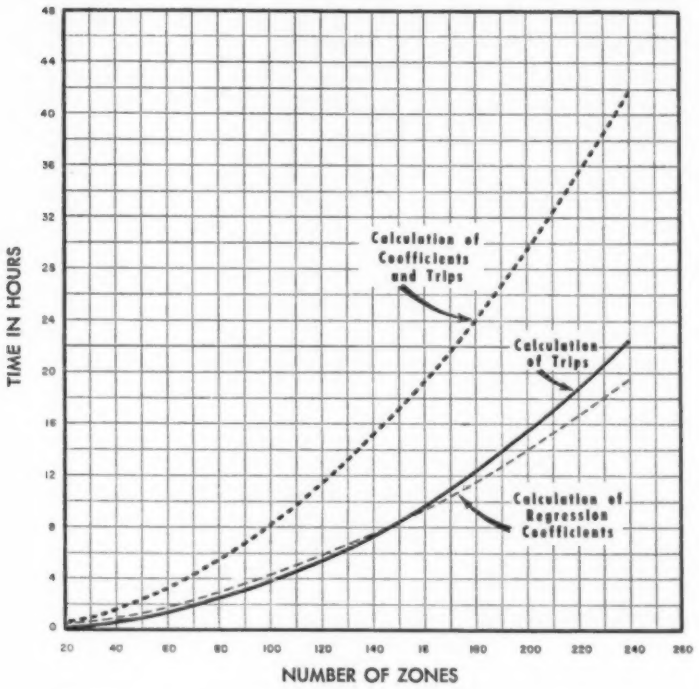


Chart H. Computation time for multiple regression method.

the Vallejo area. The regression equations determined for Vallejo were applied and design year (1980) trip values obtained. The final equation form used is shown on Chart I. However, the equation developed for San Diego was originally tried and the results were found to be unsatisfactory. It was felt that the results were affected by the differences between over-all area size, differences between trip length, as shown on Chart F, and the relatively great differences in zero trip interchanges encountered in the two areas. The distance factor was adjusted until a satisfactory function was developed.

A limitation of the San Diego equation shown on Chart I was the use of a land-use index factor based on origins per person. Such a factor would not be able to provide for growth in a design year prediction. Another objection was the use of two highly correlated

DEFINITION OF SYMBOLS

VARIABLE	SURVEY DATA	THEORETICAL DATA
Trips between pairs of zones or a cordon station and zone*	Y	Y'
Distance between zones or from station to zone**	D	D'
Population in each zone	P	P'
Employed persons in each zone	E	E'
Vehicles owned by persons in each zone	V	V'
Commercial acreage in each zone	C	C'
Industrial acreage in each zone	I	I'
Land use index of each zone	L	L'

MODELS

$$Y = A_0 + A_1X_1 + A_2X_2 + A_3X_3 + A_4X_4$$

$$Y' = A_0 + A_1X_1' + A_2X_2' + A_3X_3' + A_4X_4'$$

Note: The coefficients A_0, A_1, A_2, A_3 & A_4 are determined by least squares fit

MODESTO EQUATION

$$Y = A_0 + A_1\frac{P}{(1+D)^2} + A_2\frac{E^2}{(1+D)^2} + A_3\frac{V}{(1+D)^2} + A_4\frac{L}{(1+D)^2}$$

SAN DIEGO EQUATION

$$Y = A_0 + A_1\frac{P^2}{D^{1.5}} + A_2\frac{E^2}{D^{1.5}} + A_3\frac{V}{D^{1.5}} + A_4\frac{L}{D^{1.5}}$$

VALLEJO EQUATION FORM #1 (MODIFICATION OF SAN DIEGO EQUATION)

$$Y = A_0 + A_1\frac{P^2}{(1+D)^2} + A_2\frac{E^2}{(1+D)^2} + A_3\frac{V}{(1+D)^2} + A_4\frac{L}{(1+D)^2}$$

VALLEJO EQUATION FORM #2

$$Y = A_0 + A_1\frac{\sqrt{PV}}{(1+D)^2} + A_2\frac{E^2}{(1+D)^2} + A_3\frac{C}{(1+D)^2} + A_4\frac{I}{(1+D)^2}$$

Chart I. Mathematical models and related data.

*Including intra-zone trips.
**Average straight line distance or straight line distance between zones is used, except where barriers or other factors require adjustment. For cordon station to zone, the distances are taken along routes subjectively judged as best routes.

variables, such as population and vehicles, in a net regression model since they tend to operate against one another and not provide for growth in design year prediction. Therefore, an attempt was made to use different zonal characteristics to describe the zones within the Vallejo Study area. The characteristics used for the final Vallejo equation shown on Chart I are: employees, commercial

acres, industrial acres, straight-line distance between zones, and the cross product of population and vehicles.

Two areas which presented trip prediction problems for both the survey year and the design year were the two military installations: Mare Island Naval Shipyard and the Benicia Arsenal. The characteristics of these zones—employees and industrial acreage—were out of proportion to the rest of the study area. Detailed information on items for the two areas was not obtainable. Intrazonal movements were also not available. It was therefore decided that the best results would be obtained when predictions for the two areas were made as if they were cordon stations.

The resultant equations for Vallejo were considered acceptable for prediction of design year traffic for the following reasons: The general fit of the equation was good with no excessive differences between the actual and theoretical values. The root mean square error was only thirty-five trips as compared to forty-five trips using the San Diego equation. The coefficients developed exhibited the desirable characteristic of being positive in the large growth factors, whereas with the San Diego equation many of the growth characteristic coefficients were negative. The regression coefficients developed were applied to the design year data for Vallejo, and the over-all growth of the number of trips by zone was considered satisfactory when compared with the growth factors of the zone. (In two zones which contained a small number of origin trips, it was felt that the number of trips predicted did not come up to the desired total. The data for these two zones will be processed with an over-all equation form which has been developed for Vallejo).

The two over-all equations developed for Vallejo exhibited the same growth-characteristic coefficients as the individual equations, and when applied to the survey year data had a root mean square error of 73 with fairly good fit.

Individual equations were developed from the Modesto data using the Vallejo equation form. The same general observation can be made for the Modesto results as for Vallejo except that the fit was not quite as good—the root mean square error was 56 trips. It was felt that some of this difference could be the result of the way in which the distances in the two zones were measured. The measurement of distance is discussed later.

The two sets of over-all equation coefficients developed for

Modesto were processed with both the Modesto and Vallejo data, and the two sets of over-all equation coefficients for Vallejo were processed with the Modesto data. This was our first attempt to apply the actual equation of one city to another; and as can be seen from Charts G-2 and G-3, the over-all root mean square error differs by only seven trips.

It is hoped that a specific use of the over-all equation can be made for a zone which does not fall within the growth patterns of the other zones within a study area or where a zone has no growth characteristics in a survey year. For special problem areas, such as were found in Vallejo, the possibility of using the over-all equation for predicting the trip movements of these zones will be explored in the future.

Limitations of the Multiple Regression Method

The multiple regression method of urban area traffic prediction has several limitations which must be considered. The problem of determining the effect of individual characteristics on an equation form must almost be empirical when the net regression effect of the variables is not completely developed or understood. When an equation form is found, which, by the criteria of fit, describes the survey year data, it may be valueless for predicting trip transfers for a design year. This can be caused by the regression coefficients of the "growth" characteristics being negative, giving a decrease in the number of trips while all the other characteristics may increase. This may be caused by such things as highly correlated variables, variables not descriptive of the area, or an incorrect equation form.

With the regression method it is also possible to compute negative trip values which must be set to zero to retain any meaning in traffic prediction. This can give an upward bias in the over-all trip totals.

Computation Time for the Regression Method

The initial research using regression models for urban area traffic-determination by a computer was performed under the general library program, "A Regression Analysis Program," devel-

oped by the Shell Oil Company, and an extension program for calculating trip transfers, written in *Fortransit* by the staff of the Planning Survey Section. Many of the features of the general library program are unnecessary and time-consuming for developing regression models. Therefore, specialized regression traffic-determination programs were developed for use in urban area traffic-forecasting problems. These programs incorporate information that can be used in determining the level of accuracy of the model being tested as well as the basic calculation of estimated trips. The traffic-determination programs effected at least a 75 percent time saving over the previous programs. The time required for calculation of trip transfers by the specialized programs is based on the number of zones involved in the study area as shown in Chart H.

An example of the time required for the processing of seventy zones by the different methods follows:

The calculation of transfers for seventy zones by the regression method takes approximately four hours. The Fratar Method, with four approximations and assuming 25 percent of initial trip transfers to be zero, takes two and a half hours. The "Regression Analysis Program" used in connection with the extension program takes approximately twenty hours. The regression method, however, is designed so that, in addition to individual equations for each zone, two over-all equations for the whole area can be developed and trip transfers determined in an additional two hours. Additional time savings could be made by preparing specialized regression programs to obtain the design year trip transfers.

Definition of a Zone

The boundaries of a zone in a metropolitan traffic study are normally determined by the system of existing roads and streets as well as the proposed system to be studied. The size of the zone and its shape are normally determined by the relationship of the zone centroid to the system being studied. To facilitate the use of the multiple regression analysis, consideration should be given to the following items:

1. The zone boundaries should include the present land uses and the assumed design year land uses.

2. Any special land-use area—such as a single recreation area, school, or city dump—should be included in its entirety in one zone.

3. Natural and man-made means of confining different types of land utilization—such as rivers, freeways, canals, and railroads, which in themselves may or may not be impediments to direct routes of travel—should be used as zone boundaries.

4. Significant land areas with only scattered industry, housing, or other zonal characteristics should be excluded from contiguous zones.

5. Square areas, rather than rectangular or irregular shapes, are to be preferred for zone boundaries within the limitations as listed under 3 above.

6. If practicable, the zones should be roughly uniform in size throughout the area.

7. Zones with a single land-use classification are not desirable except as noted in 4 above.

Distances Used

The measurement of zone-to-zone distance in Vallejo differed from the measurement of that distance used in other areas, in that the straight-line distance of each trip between a pair of zones was calculated mechanically and then all distances averaged to determine the average straight-line distance between that pair of zones. Distance, as measured in Modesto and San Diego, was the straight-line distance from zone centroid to zone centroid where the zone centroid was placed arbitrarily in the center of the observed activity.

The distance of intrazone travel for the San Diego and Modesto study areas was an arbitrary measurement based roughly on the sizes of zones and the placement of characteristics within the zones. The distance of intrazone travel for the Vallejo study area was measured in the same manner as the zone-to-zone distance except in those zones which had no intrazone trips. For these zones the measurement of distance was arbitrarily chosen in the same manner as for San Diego and Modesto. The distance of travel from a cordon station to zone was the actual route distance which was arbitrarily judged the best.

We believe that we have developed a useful tool for traffic estimation which is dependent upon a metropolitan-type origin

and destination survey for the basic data needed for estimating design year trips: We can estimate design year traffic for stage construction of a complicated system for a metropolitan area; we can also provide as unbiased an estimate as it is possible to develop using basic data that should be available in any metropolitan planning department.[5]

While the results obtained to date indicate that it is not advisable to use estimating equations developed for one area in another area (because one equation model will not necessarily be the best model for another study area), this phase of the problem certainly warrants further investigation.

5. Invaluable assistance was given in the preparation of this article by the personnel responsible for the basic research: Mr. Edmond A. Radsliff, Senior Statistician, and Mr. Robert A. Bieber, Associate Statistician.